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PATENT COOPERATION TREATY

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NOTIFICATION OF ELECTION

(PCT Rule 61.2)

From the INTERNATIONAL BUREAU

To:

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 CP2/5C24
 Arlington, VA 22202
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 in its capacity as elected Office

Date of mailing (day/month/year) 17 November 2000 (17.11.00)	
International application No. PCT/AU99/00873	Applicant's or agent's file reference 2/7425/PC-MA
International filing date (day/month/year) 12 October 1999 (12.10.99)	Priority date (day/month/year) 12 October 1998 (12.10.98)
Applicant ROSE, Ian, Alexander	

1. The designated Office is hereby notified of its election made:



in the demand filed with the International Preliminary Examining Authority on:

02 May 2000 (02.05.00)



in a notice effecting later election filed with the International Bureau on:

2. The election ☒ was

was not

made before the expiration of 19 months from the priority date or, where Rule 32 applies, within the time limit under Rule 32.2(b).

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Facsimile No.: (41-22) 740.14.35	Telephone No.: (41-22) 338.83.38

PATENT COOPERATION TREATY

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From the INTERNATIONAL BUREAU

NOTIFICATION OF THE RECORDING
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Administrative Instructions, Section 422)

To:

FISHER ADAMS KELLY
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10 Eagle Street
Brisbane, QLD 4000
AUSTRALIE

Date of mailing (day/month/year) 06 April 2001 (06.04.01)	IMPORTANT NOTIFICATION
Applicant's or agent's file reference 2/7425/PC-MA	
International application No. PCT/AU99/00873	International filing date (day/month/year) 12 October 1999 (12.10.99)

1. The following indications appeared on record concerning:		
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Name and Address ASTRACON INC. 10303 East Dry Creek Road Suite 250 Englewood, CO 80112 United States of America	State of Nationality US	State of Residence US
	Telephone No. + 1.720.895.8500	
	Facsimile No. + 1.720.895.8555	
	Teleprinter No.	
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Name and Address ASTRACON INC. 6560 S. Greenwood Plaza Boulevard Suite 200 Englewood, CO 80111 United States of America	State of Nationality US	State of Residence US
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PATENT COOPERATION TREATY

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International application No. PCT/AU99/00873	International filing date (day/month/year) 12 October 1999 (12.10.99)

1. The following indications appeared on record concerning:		
<input checked="" type="checkbox"/> the applicant	<input checked="" type="checkbox"/> the inventor	<input type="checkbox"/> the agent <input type="checkbox"/> the common representative
Name and Address ROSE, Ian, Alexander 16 Pedley Street Wavell Heights, QLD 4012 Australia	State of Nationality AU	State of Residence AU
	Telephone No.	
	Facsimile No.	
	Teleprinter No.	
2. The International Bureau hereby notifies the applicant that the following change has been recorded concerning:		
<input type="checkbox"/> the person	<input type="checkbox"/> the name	<input checked="" type="checkbox"/> the address <input type="checkbox"/> the nationality <input type="checkbox"/> the residence
Name and Address ROSE, Ian, Alexander 15 Harriet Street Red Hill, QLD 4059 Australia	State of Nationality AU	State of Residence AU
	Telephone No.	
	Facsimile No.	
	Teleprinter No.	
3. Further observations, if necessary:		
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ART 34 AMDT

Suitably the data structure comprises a graph of cost nodes wherein each node specifies the cost of particular features or sets of features for respective paths.

The cost nodes in the graph may be either internal for representing links between internal terminations in the connection model or external for the terminations at said predetermined locations.

In another arrangement the cost model represents path cost as code which is executed by the processing means.

Suitably the processing means for executing the code is an implementation of a Turing machine.

If required the cost model further exposes the delay in implementing functional features supported by the path.

Where the cost model indicates implementation delay, the client requirement for a connection may include a desired minimum delay.

Suitably, individual terminations at the same location that have common attributes are represented as termination groups.

In another form the invention resides in a connection manager for selecting paths from a plurality of paths available from service providers in a communications network to route broadband traffic in the network, wherein the connection manager includes:

- (a) a cost model provided by the service provider that exposes to clients the cost of using each path; and
- (b) processing means, operated in response to a client requirement for a connection involving a plurality of terminations in the network, to -
 - (i) identify candidate paths for routing communications traffic amongst said plurality of terminations and
 - (ii) determine, from the candidate paths and on the basis of cost exposed by the cost model, a least cost selection of paths connecting said terminations.

The cost model suitably also exposes delay in the respective service provider making a path available.

The available paths may include paths pre-existing in the network and/or paths which can be created by the respective service provider.

If required, the cost model suitably exposes usage cost depending on functional features required of each path.

Most suitably the cost model is transferred from each service provider.

The service providers may include network managers for management of
5 network elements.

The connection manager may be installed in an environment wherein its client is a superior connection manager and a superior cost model is constructed from an aggregate of cost models transferred by subordinate connection managers.

10 In a further form, the invention resides in a selection method for selecting paths from a plurality of paths available from service providers in a communications network to route broadband traffic in the network, including the steps of:

- 15 (a) creating a connection model that indicates functional features supported by each path in the network and locations of terminations for respective paths;
- (b) creating a cost model associated with the connection model that exposes to clients the cost of using the functional features for each path; and
- (c) processing a client requirement for a connection with desired features between two locations in the network by -
 - 20 (i) identifying, from the connection model in light of the desired features, candidate paths for routing communications traffic between the two locations and
 - (ii) determining, from the candidate paths and on the basis of the cost exposed by the cost model, an optimal selection of paths connecting
25 said locations.

Suitably the step of creating the connection model reflects attributes of network elements deployed by the service provider.

30 In a yet further form the invention resides in a method of managing selection of a path from a plurality of paths available from service providers in a communications network to route broadband traffic in the network, said method including the steps of:

- (a) providing a cost model whereby the service provider exposes usage cost of each path in the network; and
- (b) processing a client requirement for a connection involving a plurality of terminations by -
 - (i) identifying candidate paths for routing communications traffic amongst said plurality of terminations, and
 - (ii) determining, from the candidate paths and on the basis of cost exposed by the cost model, a least cost selection of paths connecting said terminations.

10 Preferably the cost model is transferred from the service provider.

The method of managing selection may be undertaken in an environment wherein the client is a superior connection manager and a superior cost model is constructed from an aggregate of cost models transferred by subordinate connection managers.

15 BRIEF DETAILS OF THE DRAWINGS

To assist in understanding the invention preferred embodiments will now be described with reference to the following figures in which:

FIG. 1 is a diagram of a heterogeneous communications network including a hierarchy of connection managers;

20 FIG. 2A is a diagram illustrating the structure of a connection manager of a first embodiment;

FIG. 2B is a diagram illustrating interaction of a connection manager of a further embodiment with service providers;

25 FIG. 3 is a diagram of a world view from the perspective of the abstract connection model of the first embodiment;

FIG. 4 is an illustration of the physical architecture of an example network;

FIG. 5 is a top level view of a connection model for the network of FIG. 4;

FIG. 6A is a schematic diagram of an access device;

FIG. 6B is a cost graph for the access device of FIG. 6A;

30 FIG. 7A is a schematic diagram of a multiplexer;

FIG. 7B is a cost graph for the multiplexer of FIG. 7A;

FIG. 8A is a schematic diagram of an edge switch;

FIG. 8B is a cost graph of the edge switch of FIG. 8A;

- (ii) reduction in network capacity experienced in implementing the path; and
- (iii) funds required to implement the path.

5 5. The connection manager as claimed in any one of claims 1 to 4 wherein the cost model represents path cost as a data structure which is interpreted by the processing means.

10 6. The connection manager as claimed in claim 5 wherein the data structure comprises a graph of cost nodes and each node specifies the cost of particular features or sets of features for respective paths.

15 7. The connection manager as claimed in claim 6 wherein the cost nodes in the graph may be either internal for representing links between internal terminations in the connection model or external for the terminations at said predetermined locations.

8. The connection manager as claimed in any one of claims 1 to 4 wherein the cost model represents path cost as code which is executed by the processing means.

20 9. The connection manager as claimed in claim 8 wherein the processing means for executing the code is an implementation of a Turing machine.

25 10. The connection manager as claimed in any one of claims 1 to 9 wherein the cost model further exposes the delay in implementing functional features supported by the path.

30 11. The connection manager as claimed in claim 10 wherein the client requirement for a connection includes a desired minimum delay which is utilised as a further basis for determining the optimal selection of paths.

12. The connection manager as claimed in any one of the preceding claims wherein individual terminations at the same location that have common attributes are represented as termination groups.

13. A connection manager for selecting paths from a plurality of paths available from service providers in a communications network to route broadband traffic in the network, wherein the connection manager includes:

- 5 (a) a cost model provided by the service provider that exposes to clients the cost of using each path; and
- (b) processing means, operated in response to a client requirement for a connection involving a plurality of terminations in the network, to -
- 10 (i) identify candidate paths for routing communications traffic amongst said plurality of terminations and
- (ii) determine, from the candidate paths and on the basis of cost exposed by the cost model, a least cost selection of paths connecting said terminations.

15 14. The connection manager as claimed in claim 13 wherein the cost model also exposes delay in the service provider making a path available.

20 15. The connection manager as claimed in either claim 13 or claim 14 wherein available paths include paths pre-existing in the network.

16. The connection manager as claimed in either claim 13 or 14 wherein available paths include paths that can be created by the service provider.

25 17. The connection manager as claimed in any one of claims 13 to 16 wherein the cost model exposes usage cost depending on the functional features required of each path.

30 18. The connection manager as claimed in any one of claims 13 to 16 wherein the cost exposed by the cost model reflects the resources required to implement a path having a particular set of features.

19. The connection manager as claimed in any one of claims 13 to 18 wherein the path cost is determined in accordance with one or more of:

- (i) number of network elements involved in the path;
- (ii) reduction in network capacity experienced in implementing the path;
and
- (iii) funds required to implement the path.

5

20. The connection manager as claimed in any one of claims 13 to 19 wherein the cost model represents path cost as a data structure which is interpreted by the processing means.

10 21. The connection manager as claimed in any one of claims 13 to 20 wherein the cost model represents path cost as code which is executed by the processing means.

22. The connection manager as claimed in any one of claims 13 to 21 wherein a
15 cost model is transferred from each service provider.

23. The connection manager as claimed in any one of claims 13 to 22 wherein the client is a superior connection manager and a superior cost model is constructed from an aggregate of cost models transferred by subordinate connection managers.

20

24. A selection method for selecting paths, from a plurality of paths available from service providers in a communications network, to route broadband traffic in the network, including the steps of:

- (a) creating a connection model that indicates functional features supported by
25 each path in the network and locations of terminations for respective paths;
- (b) creating a cost model associated with the connection model that exposes to clients the cost of using the functional features for each path; and
- (c) processing a client requirement for a connection with desired features between two locations in the network by -
30 (i) identifying, from the connection model in light of the desired features, suitable candidate paths for routing communications traffic between the two locations and

- (ii) determining, from the candidate paths and on the basis of the cost exposed by the service provider, an optimal selection of paths connecting said locations.

5 25. The selection method of claim 24 wherein the step of creating the connection model reflects attributes of network elements deployed by each service provider.

10 26. A method of managing selection of paths from a plurality of paths available from service providers in a communications network to route broadband traffic in the network, said method including the steps of:

- (a) creating a cost model whereby a service provider exposes to clients the cost of using each path;
- (b) processing a client requirement for a connection involving a plurality of terminations by
 - 15 (i) identifying candidate paths for routing communications traffic amongst said plurality of terminations and
 - (ii) determining, from the candidate paths and on the basis of cost exposed by the cost model, a least cost selection of paths connecting
 - 20 said terminations.

27. The method of managing selection as claimed in claim 26 wherein the cost model is transferred from the service provider.

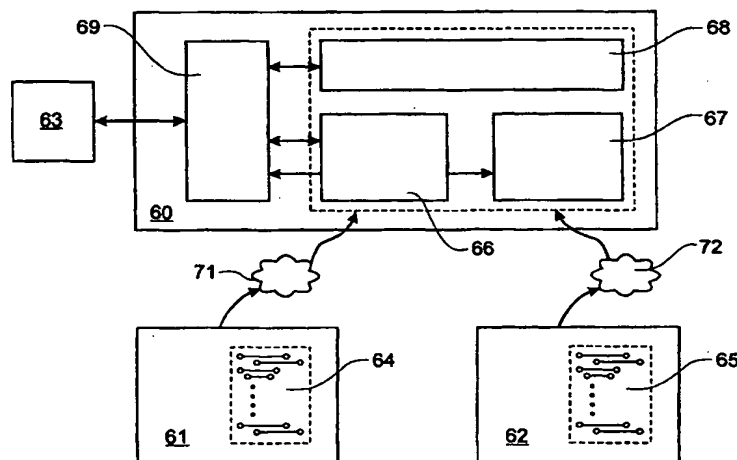
25 28. The method of managing route selection as claimed in either claim 26 or claim 27, wherein the client is a superior connection manager and a superior cost model is constructed from an aggregate of cost models transferred from subordinate connection managers.



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(54) Title: MANAGEMENT OF PATH SELECTION IN A COMMUNICATIONS NETWORK



(57) Abstract

A connection manager (60) is provided for selecting paths from a plurality of paths (64, 65) available from service providers (61, 62) in a communications network to route broadband traffic in the network. The connection manager (60) includes a connection model (66) indicating functional features supported by each path in the network and locations of terminations for respective paths; a cost model (68) associated with the connection model that exposes the cost of using the functional features for each path (64); and a processing means (69). The processing means of the connection manager is operative, in response to a client (63) requirement for a connection with desired features between specified locations in the network, first to identify, from the connection model (66) in light of the desired features, suitable candidate paths for routing communications traffic between the specified locations and, secondly to determine from the candidate paths and on the basis of cost exposed by the cost model (69), an optimal selection of paths connecting said locations.

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MANAGEMENT OF PATH SELECTION IN A COMMUNICATIONS NETWORK

FIELD OF THE INVENTION

5 This invention relates to the management of connections in a large scale heterogeneous communications network, such as those operated by telecommunications utility companies and utilised by different carriers and service providers. In particular the invention relates to a method and apparatus for selecting paths in a broadband network that may be provided to customers requiring a
10 communications service.

BACKGROUND TO THE INVENTION

 The term "communications network" as used in the specification, is meant to encompass networks suitable for voice telephony and for data communications.
15 Such communications networks may be suitable for switching and transporting voice, data, sound and/or image traffic, otherwise referred to as broadband or "multimedia" communications.

 Existing communications networks are characterised by a number of transmission mediums using a variety of network technologies, protocols, software
20 applications and equipment sourced from different vendors. Whilst much of the equipment includes management functions, such as monitoring, test and alarm features; the centralising, handling and controlling of network management functions in a complex multi-vendor environment is a significant problem.

 A further problem in a heterogeneous network - which might include
25 customer access technologies (ADSL, HFC), core network technologies (ATM, frame relay) and transmission technologies (SONET/SDH, WDM) - is that the management of end-to-end connections is typically conducted according to a lowest common denominator philosophy. The services provided by the network are limited to those able to be supported by the least capable equipment in the network.
30 This philosophy is very ineffective in utilising the full capability of the diverse communications paths available in a network to meet particular service requirements of customers.

Glossary

	AAD:	ATM access device
	ADSL:	advanced digital subscriber line
	ATM:	asynchronous transfer mode
5	CMIP:	common management information protocol
	CORBA:	common object request broker architecture
	EMS:	element management system
	HFC:	hybrid fibre-optic co-axial
	NMS:	network management system
10	NTU:	network terminal unit
	OSS:	operational support system
	VPC:	virtual path connection
	SDH:	synchronous digital hierarchy
	SNMP:	simple network management protocol
15	SONET:	synchronous optical network
	TCP/IP:	transmission control protocol / Internet protocol
	TL/1:	Bellcore interface protocol for network management
	VCI:	virtual circuit identifier
	VPI:	virtual path identifier
20	WDM:	wave division multiplexing

OBJECT OF THE INVENTION

It is an object of the present invention to provide a connection manager for selecting paths from a plurality of paths available in a communications network to
 25 route broadband traffic between predetermined locations in the network which ameliorates or overcomes at least some of the problems associated with the prior art.

It is another object of the invention to provide a path selection method for use in a communications network contributing to cost effective use of path features
 30 for routing broadband traffic between predetermined locations in the network.

Further objects will be evident from the following description.

DISCLOSURE OF THE INVENTION

In a form, the invention resides in a connection manager for selecting paths from a plurality of paths available from service providers in a communications network to route broadband traffic in the network, wherein the connection manager
5 includes:

- (a) a connection model indicating functional features supported by each path in the network and locations of terminations for respective paths;
- (b) a cost model associated with the connection model that exposes to clients the cost of using the functional features for each path; and
- 10 (c) processing means, operated in response to a client requirement for a connection with desired features between two locations in the network, to -
 - (i) identify, from the connection model in light of the desired features, candidate paths for routing communications traffic between the two locations and
 - 15 (ii) determine, from the candidate paths and on the basis of cost exposed by the cost model, an optimal selection of paths connecting said locations.

Preferably the functional features indicated by the connection model include one or more of the following:

- 20 (i) communications protocol;
- (ii) transmission rate;
- (iii) availability of the path; and/or
- (iv) average error rate.

Preferably the cost exposed by the cost model reflects the resources required
25 to implement a path having a particular set of features.

The path cost may be determined in accordance with the service provider's business rules or technical requirements, including one or more of:

- (i) number of network elements involved in the path;
- (ii) reduction in network capacity experienced in implementing the path;
- 30 and/or
- (iii) funds required to implement the path.

In one arrangement the cost model represents path cost as a data structure which is interpreted by the processing means.

Suitably the data structure comprises a graph of cost nodes wherein each node specifies the cost of particular features or sets of features for respective paths.

The cost nodes in the graph may be either internal for representing links between internal terminations in the connection model or external for the terminations at said predetermined locations.

In another arrangement the cost model represents path cost as code which is executed by the processing means.

Suitably the processing means for executing the code is an implementation of a Turing machine.

If required the cost model further exposes the delay in implementing functional features supported by the path.

Where the cost model indicates implementation delay, the client requirement for a connection may include a desired minimum delay.

Suitably, individual terminations at the same location that have common attributes are represented as termination groups.

In another form the invention resides in a connection manager for selecting paths from a plurality of paths available from service providers in a communications network to route broadband traffic in the network, wherein the connection manager includes:

- (a) a cost model provided by the service provider that exposes to clients the cost of using each path; and
- (b) processing means, operated in response to a client requirement for a connection involving a plurality of terminations in the network, to -
 - (i) identify candidate paths for routing communications traffic amongst said plurality of terminations and
 - (ii) determine, from the candidate paths and on the basis of cost exposed by the cost model, a least cost selection of paths connecting said terminations.

The cost model suitably also exposes delay in the respective service provider making a path available.

The available paths may include paths pre-existing in the network and/or paths which can be created by the respective service provider.

If required, the cost model suitably exposes usage cost depending on functional features required of each path.

Most suitably the cost model is transferred from each service provider.

The service providers may include network managers for management of
5 network elements.

The connection manager may be installed in an environment wherein its client is a superior connection manager and a superior cost model is constructed from an aggregate of cost models transferred by subordinate connection managers.

10 In a further form, the invention resides in a selection method for selecting paths from a plurality of paths available from service providers in a communications network to route broadband traffic in the network, including the steps of:

- 15 (a) creating a connection model that indicates functional features supported by each path in the network and locations of terminations for respective paths;
- (b) creating a cost model associated with the connection model that exposes to clients the cost of using the functional features for each path; and
- (c) processing a client requirement for a connection with desired features between two locations in the network by -
 - 20 (i) identifying, from the connection model in light of the desired features, candidate paths for routing communications traffic between the two locations and
 - (ii) determining, from the candidate paths and on the basis of the cost exposed by the cost model, an optimal selection of paths connecting
25 said locations.

Suitably the step of creating the connection model reflects attributes of network elements deployed by the service provider.

In a yet further form the invention resides in a method of managing selection
30 of a path from a plurality of paths available from service providers in a communications network to route broadband traffic in the network, said method including the steps of:

- (a) providing a cost model whereby the service provider exposes usage cost of each path in the network; and
- (b) processing a client requirement for a connection involving a plurality of terminations by -
- 5 (i) identifying candidate paths for routing communications traffic amongst said plurality of terminations, and
- (ii) determining, from the candidate paths and on the basis of cost exposed by the cost model, a least cost selection of paths connecting said terminations.

10 Preferably the cost model is transferred from the service provider.

The method of managing selection may be undertaken in an environment wherein the client is a superior connection manager and a superior cost model is constructed from an aggregate of cost models transferred by subordinate connection managers.

15

BRIEF DETAILS OF THE DRAWINGS

To assist in understanding the invention preferred embodiments will now be described with reference to the following figures in which:

FIG. 1 is a diagram of a heterogeneous communications network including a hierarchy of connection managers;

20 FIG. 2A is a diagram illustrating the structure of a connection manager of a first embodiment;

FIG. 2B is a diagram illustrating interaction of a connection manager of a further embodiment with service providers;

25 FIG. 3 is a diagram of a world view from the perspective of the abstract connection model of the first embodiment;

FIG. 4 is an illustration of the physical architecture of an example network;

FIG. 5 is a top level view of a connection model for the network of FIG. 4;

FIG. 6A is a schematic diagram of an access device;

FIG. 6B is a cost graph for the access device of FIG. 6A;

30 FIG. 7A is a schematic diagram of a multiplexer;

FIG. 7B is a cost graph for the multiplexer of FIG. 7A;

FIG. 8A is a schematic diagram of an edge switch;

FIG. 8B is a cost graph of the edge switch of FIG. 8A;

FIG. 9 is a cost graph of a core switch supporting local switching;

FIG. 10 is an alternative cost graph of the core switch of FIG. 9;

FIG. 11 is shows a proposed (cost-free) link between two cost graphs;

FIG. 12 is shows a link between the cost graphs of FIG. 11;

5 FIG. 13A shows a proposed link between two further cost graphs;

FIG. 13B shows an aggregated cost graph of the two further cost graphs;

FIG. 14 shows a aggregated cost graph for the core domain of the network of FIG. 4;

FIG. 15 shows a cost graph used for modeling the network of FIG. 4;

10 FIG. 16 shows the cost graph of FIG. 15 re-shaped to illustrate a preferred path selection method;

FIG. 17 illustrates the principles of the path selection method; and

FIG. 18 illustrates the path selection method applied to the re-shaped cost graph of FIG. 16.

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DETAILED DESCRIPTION OF THE DRAWINGS

The embodiment of the invention is described in the environment of a heterogeneous communications network 10 as illustrated in FIG. 1. The connection manager of the embodiment participates in the service activation and service assurance processes of large communications networks. The connection manager is suited to use in relation to broadband communications products which have significant complexity at the "Network Layer" (as defined by the ITU-T layered management model) - such as ATM, SDH, IP and bundled broadband products. The connection manager supports configuration and security activities at the Network Layer and can cooperate with other systems performing these functions for subsets of the communications network. The connection manager of the embodiment resides in a network management layer 30 between the service layer 20 and the network element layer 40.

The service layer 20 typically includes service order systems 21 which institute the creation of new connections and facilitates the query, modification and deletion of existing connections and pre-sales systems 23 which support pre-sales activities including inquiries regarding available connection characteristics,

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connection cost and time frame. Examples of service layer systems include service order, customer network management (CNM) or wholesale gateway.

The network element layer 40 typically includes the hardware for providing network services such as switching or transmission, for example ADSL/HFC customer access technologies 41, ATM core network broadband technologies 42, and transport technologies 43 such as SONET/SDH or WDM. The network element hardware may be conceptually considered to reside in different "domains" and is typically also proprietary in nature. Accordingly, the network element hardware generally uses proprietary or compatible network element managers which act as proxies for many of the network elements.

Examples of network element managers are EMS systems 44 and 45 for the ADSL/HFC hardware, the NMS 46 for the ATM core hardware and the vendor specific NMS 47, 48 for the transport domain. Although the network element managers manage many network elements, they expose each network element as an individual entity. Thus in other embodiments, the connection manager may interface directly to the network elements.

The network management layer 30 of the embodiment illustrates the flexibility of the connection manager. A first connection manager 31 is interfaced to the EMS systems 44 and 45 for managing the customer access domain 40A. The functional flexibility of the connection manager arises from its ability to manage the functionally different requirements of the switch matrix EMS 44 and the AAD EMS 45. A second connection manager 32 manages the core domain 40C and a third connection manager 33 is interfaced to the vendor NMS systems 47 and 48 in the transport domain 40T. The transport domain illustrates the ability of the connection manager to handle disparate vendor equipment. The connection managers include interfaces which communicate using the CMIP, SNMP, TL/1 or proprietary protocols as required. These interfaces may be adapted to suit particular vendors' equipment, current or future.

A fourth superior connection manager 34 is interfaced with the three domain connection managers 31, 32 and 33 for the purpose of cross-domain connection management. The superior or cross-domain manager 34 level accepts end-to-end connection instructions for the entire network, it determines which paths through the underlying networks are available and issues connection instructions to the

domain connection managers as appropriate. The connection task is thus delegated to the appropriate domain connection managers.

Although shown as four separate managers, the network management layer 30 may be viewed as undertaking the overall connection management function for the network, with the cross-domain connection and domain connection being managed at different levels. Thus the network wide connection requirement is simplified step by step so that each level of connection management can be optimised to manage the portions of the network under its control. However, the separate connection managers illustrate the distributed nature of a network wide connection manager 35 which may be geographically distributed across a large number of sites and network operations centres.

Network Models

The connection manager provides flexible network modeling tools for representing a service provider or network owner's view of broadband connections. The key concepts for these representations are:

- (i) "paths" which represent the network owner's view of a connection having the ability to transmit data over a communications network, such as ATM PVC;
- (ii) "terminations" where the path is manifest outside of a network, such as an ATM VPI, VCI and cable, or a customer NTU; and
- (iii) "features" which are the external selectable characteristics of the path visible at its terminations, such as quality of service, bit rate or path diversity.

Conceptually a path can negotiate many network elements and protocols, such as end-to-end SDH connections implemented using SDH switches and WDM transmission.

Connection Manager Structure

The structure of a generic connection manager 35 of one embodiment is described in relation to FIG. 2A, as it might be deployed in relation to a particular network. A connection model 36 is used to expose to clients the network and its services, which model may be implemented by the core software 37 for execution by a processor (not shown) or a series of distribute processors. Network adapters 38 are provided to interface with network elements, EMS or other NMS; whilst service adaptors 39 are provided to interface to existing service OSS.

The connection manager 35 supports several fundamental operations relating to the life cycle of a path. The service provider or network owner may instruct that a path be *reserved*, *created* or *changed*, which results in the automatic selection, allocation and configuration of appropriate network equipment to
5 implement a connection with the specified features between specified terminations. A *remove* operation frees the allocated network equipment.

The connection manager allows the determination of which features are supported, in what combinations and at what localities in the network. Terminations and paths may be searched and listed, and the termination which best supports a
10 given set of features in a locality suggested to a client by the connection manager.

The connection manager 35 of the embodiment preferably uses a CORBA IIOP architecture to interface to both the service layer and the network layer. The service layer interface and the network model can be adapted to present some standard data models, such as ETSI 600-653 or ATM Forum M4, or adapted to
15 existing service layer interfaces. All connection manager objects can be annotated with the names and identifiers required by external systems, for example customer circuit identifiers.

The connection manager is a high-availability system supporting on-line changes to configuration with back-out, on-line database backup, replicated
20 databases and redundant hardware. Depending on configuration, the connection manager will support 10,000 transactions per hour on one mid-range server machine (for example Hewlett Packard J-class). This typically corresponds to a network with 50 million installed paths with a typical operational latency is 0.3 seconds.

One connection manager installation can be distributed, as indicated above,
25 over a number of server machines. A distributed installation on up to 10 machines would be typical, as transaction processing scales approximately linearly over this range. Such installation can suitably support HP UX or Solaris on SUN Solaris, Microsoft's NT on Intel or PA-RISC operating systems. OracleTM database and OrbixTM ORB are also used in the preferred embodiment.

30 FIG. 3 shows a view of the world from the perspective of a connection model, considered in the abstract. A connection model is a framework for describing communications systems involving connections. In particular, the abstract connection model 50 of the embodiment is a distributed, object oriented

way of representing the state and operations required to manage the network layer 30 of a broadband communications network. The service layer 20 is effectively the driver for the connection model in that providing function to the service layer is the role of the connection model.

5 In order to address requests from the service layer the connection model delegates to either the network element layer 40 - in the form of either network elements 53 or network element managers 54 or other providers at the network management layer - for example workflow managers 51, network managers 52, other connection managers 55 or network service providers (NSP) 56. The choices
10 involved in performing delegation include: (a) to which subordinates are functions delegated? (b) how are super-functions mapped to subordinates? (c) what is the sequencing of subordinate operations? and (d) what actions occur when a subordinate operation fails?

The abstract connection model 50 is suitably instantiated for operational use,
15 with the instantiation depending on:

- (i) the particular networking technology employed by the network owner;
- (ii) the network owner's engineering rules; and
- (iii) the network owner's service level requirements.

20 It is the model's instantiation 36 that gives meaning to the components of the model, such as path, feature and termination. When a connection model is instantiated, each of the abstract concepts that it presents will have a precise meaning. Furthermore, a model instantiation will have objects instantiated against it which objects will conform to both the abstract connection model and the
25 instantiated model.

The development of a connection manager application normally includes the following three stages:

- Network analysis and design – the focus of this stage is to define the architecture of the network to be managed and to analyse the characteristics of
30 each component of the network.
- Connection manager installation – the focus of this stage is to use the mechanisms supported by the core software to specify how the network should be managed. The installation is the outcome of this stage.

- Run time – once a connection management system is installed, paths can be created through the network to provide communications services.

Basic Concepts

The basic concepts for connection management used by the connection model are the path-termination-feature concepts, as introduced briefly above. A *feature* is a characteristic of a path that is required by a client or customer, and is manifest to the client of the path. Typical features include data transfer protocol, bandwidth, reliability and error rate; for example: ATM protocol, 64kb/s data rate and unavailability for less than 1 minute/year. Characteristics of paths such as routing via a particular network element, or implementation using a particular technology are not features, because the client cannot detect those characteristics. Features may apply to particular terminations of a path or installed on connections, which often requires feature values. The feature Maximum Bit Rate has a value specifying what the maximum bit rate is, for example Maximum Bit Rate = 256 kb/s. A feature with values applied to a connection is referred to as an *installed feature*.

A *path* is provided by a network and is fully characterised by the installed features of the path (the *path features*), a set of *terminations* exposed to the client and a set of installed features for each termination (the *termination features*). A path may be permanent, that is the ability to transmit exists at all times after the path is established by a connection manager, until it is torn down by the connection manager. A path may be switched, in which case there are two phases, 'configuration' and 'signalling'. The signalling phase initiates and finalises the ability to transfer data. Signalling emanates from network equipment connected to the path. The configuration phase is performed by a connection manager and establishes the bounds of data transfer that can be requested by signalling. For example, configuration may allow data transfer anywhere within a national network, with speed up to 20Mb/s. This would prevent signalling requesting an international transfer, or a 100Mb/s transfer.

A path typically has two terminations, but may have one or many. Examples of paths are ATM PVCs and SVCs, SDH connections, or customer access networks (ie. local loop). The term path as used herein includes the ITU-T concepts

of connection and trail, as well as further concepts such as Switched Virtual Connection.

A *network* represents the ability to manage paths and is used to create new paths and list existing paths. Paths are always totally contained within exactly one network. A network may be conceptualised as a factory of paths, and a collection of the paths that it has created. In is also a collection of the terminations at which the paths will or could be manifest. Example networks include an ATM switch, a Main Distribution Frame, a SONET ring, a ATM domain manager, a regional SDH network manager. The term 'network' includes the ITU-T concepts of network, sub-network and network element.

A network is typically implemented by calling on the services of other networks, termed *sub-networks*. For example, an ATM network may use the services of a DSL and Core ATM network. The term 'sub-network' may imply a client-server relationship between the network and the sub-network. Generally, there is nothing inherent in a network that makes it a sub-network. All sub-networks are fully fledged networks in their own right. Therefore all the properties and functions of networks are also properties and functions of sub-networks

A *termination* is where a path is, or may be, manifest to the client of a network. A termination can also include a grouping of terminations. A termination grouping may or may not be capable of establishing paths. Example terminations may be an physical port, an ATM VPI on a physical port, or a cable pair at a customer's premises. The term 'termination', includes the ITU-T concepts of trail termination point, connection termination point and access group. A termination can participate in a finite number of paths, typically one, but potentially more.

A path in a network will have one or more (usually two) terminations. Single termination paths may represent loop-back and multiple terminations may represent multiple drop (for example CSMA) or a closed user group (for example a voice private network). Paths may share terminations, this may express a multi-serving capability (such as the set of customers using a billing server).

Connection Manager

The connection manager 35, as depicted in FIG 2A, presents an architecture for assembling a working network management system. The core software 37 provides, in one embodiment, connection model abstractions that can be configured

to reflect the characteristics of the particular network equipment deployed by the network owner. The operative connection model 36, once configured, will substantially reflect the business and engineering policies of the network owner, in other words the knowledge that a human operator would apply if they were
5 performing the connection manager functions manually. The core software 37 assumes that the interface to the network supports the connection model 36, preferably expressed in CORBA.

The network adaptors 38 are developed, typically using stack products, such as those provided by Vertel or Hewlett-Packard, in order to provide simple
10 interfaces into complex protocols such as CMIS or TL/1. The service adaptors 39 provide an interface between the network's service management layer OSS. Existing operation support systems generally have a proprietary interface, although there are some emerging standards including the US Federal Communications Commission's "Gateway". Printed paper or a character terminal are common
15 interfaces. The deployed connection manager 35 preferably has an adaptor to automate the interface between the service management layer 20 and the core software 37.

Distributed Object Model

As the connection manager is a network layer manager, it is only concerned
20 with modeling network-level concepts. The first network level concept is "connection". The connection model 36 of the embodiment is a distributed object model, preferably expressed in CORBA interface definition language (IDL). In accordance with the concepts introduced earlier, there are three types of objects in the model, namely:

- 25 (i) path objects that represent connections;
- (ii) termination objects that represent where the connections are physically manifest; and
- (iii) network objects which are the fabric that can create connections.

Network Objects

30 The network object is a container of path objects and termination objects. Network objects form a hierarchy, where some network objects are superior to others. Network objects will typically form a strict containment hierarchy, though the connection manager allows any non-cyclic structure. Network objects can

represent: individual network element instances, groups of network elements organised by some owner determined criteria, such as geographic domains or functional domains; sub-networks that are managed by some other NMS, such as a vendor NMS; cross-domain networks that aggregate several domain network objects, such as those identified 40A, 40C and 40T in FIG. 1.

Network objects support the following operations: listing the capabilities of the network object; listing the characteristics of the paths that the network objects can create; creating paths having specified terminations and features; previewing path creation; searching for paths, terminations and sub-networks having specified characteristics. Network objects may be configured as follows: assigning identity, description, meaning; defining the relationships between the network objects (for example, a containment tree structure); defining the connections between subordinate network objects; and the characteristics of the paths they can create.

Path Objects

Path objects represent the connections formed by network objects. They correspond to some real-world connection concept. This could be for example:

- (i) a physical connection, such as a bearer distribution frame;
- (ii) a switched connection, such as an ATM virtual circuit; or
- (iii) some abstract relationship, such as the relationship between a customer and their Internet service provider (ISP).

A path object is always contained within one network object. When network objects form a hierarchy, a network object may implement that path by delegating portions of the implementation to sub-paths in its subordinate networks. Paths are characterised by terminations and features. Terminations describe where the path is manifest, features describe externally visible characteristics. A path generally has two terminations.

A feature has a name and optionally a value. Features are applied to either the path itself, or terminations on the path. This permits termination-specific features to be modelled - as required for asymmetrical paths.

Paths support life-cycle type operations. This allows for several levels of completeness of the path's implementation. The typical levels of implementation of paths are:

- (a) *design* - the path consumes no resources, other than those minimally needed to record its characteristics;
- (b) *reserve* - the path is fully implemented, except the last step which would enable service;
- 5 (c) *installed* - the path is implemented into the equipment to enable service; and
- (d) *deleted* - the path no longer exists, but the memory of it is kept for audit purposes.

10 Paths have a cost, which represents the amount of resource required to implement the path. The cost allows a client to rationally choose between several candidate paths, each of which is capable of supporting their needs. Path objects support the following operations: deletion; changing the features, terminations or implementation completeness; preview operations for the above; and listing the path attributes.

15 Termination Objects

Termination objects represent where path objects are (or may be) manifest. They correspond to some real-world concept for example: a physical termination, such as a cable; one channel multiplexed over some bearer such as an ATM virtual circuit or SDH container; a grouping of multiplexed channels, such as an ATM
20 virtual path. A termination object within one network object. A network may express an effectively infinite number of terminations, for example an ATM network may model each VPI/VCI as a termination. Even coarser grained modelling than the ATM example will have large numbers of terminations.

Termination objects support the following operations: describe the
25 termination; find the lowest cost free termination capable of supporting a particular set of features.

Concepts of Cost

When the core software is implementing a path, or changing an existing path, it may have several alternate methods. Each alternate will require a certain
30 amount of the network owner's or service provider's equipment resource. For example, bandwidth on a optical fibre, dedicated use of a port card, or share of switch capacity. The core suitably implements a path using the alternative that requires the least resource. To allow the connection manager to determine least

resource, the core software uses the concept of "cost". Each candidate path has a cost and each candidate termination has a cost. The connection manager suitably makes the simple choice of 'least cost'. The power comes from the meaning assigned to, and the method of calculating the cost.

5 Network objects close to the service layer typically have a huge number of candidate paths. One approach that such an object could use, is to execute the preview-path-creation operation on for each of the candidate paths, then choose the one that has the lowest overall cost. This direct approach is practically infeasible when, as is typical, there are multi-millions of candidate paths. To bypass this
10 practical difficulty, the connection manager implements the concept of cost modelling. A cost model is a way for a network's client to efficiently predict the cost of paths. This allows the client to check the millions of options, without doing millions of requests.

Cost Model

15 A cost model preferably predicts the cost of paths based on termination groups, rather than individual terminations. It supports feature-dependent costs. Cost models may be arbitrarily complex and precise. For example, a highly precise model would specify the cost for paths between each termination group pair. A coarse model would specify a single cost for all paths. Intermediate models that
20 exhibit a arbitrary mixture of termination dependent cost and fixed cost may also be supported.

 A cost offer is a named cost model that applies for a specified period of time. A cost offer is the mechanism by which a network exposes the cost model for its paths. As a cost offer includes a validity time, clients can restrict the number of
25 enquiries for cost model that they make. The present embodiment of the connection manager supports validity times from the order of seconds upwards - shorter times need higher computing resource.

 FIG 2B is a representation of a connection manager 60 of a further embodiment showing the interaction with service providers 61, 62 in response to a
30 requirement issued by a client 63 for a connection in a communications network. Each service provider has a plurality of paths 64, 65 available in the communications network. The connection manager 60 includes a connection model 66, 67 which indicates functional features supported by each path, along with

locations of terminations for the paths in respective sub-networks. The connection manager 60 further includes a cost model 68 that is associated with the connection model and exposes the cost of using the functional features to the client 63. In a preferred arrangement the cost model is transferred 71, 72 from a service provider
5 into the connection manager 60. The connection manager processing means 69, operates in response to the client requirement to first identify from the connection model 66, 67 candidate paths relevant to the specified locations and, secondly to determine on the basis of cost exposed by the cost model 68 an optimal selection from the candidate paths, which suitably meet a 'least cost' criterion. Further
10 details about a preferred cost model, explained with reference to a network fragment, follow.

There are two options available for determining costs for a network object, namely:

- (i) *fixed cost* - where a configured cost is returned; and
- 15 (ii) *mapped cost* - where a value for cost is returned that is derived from the costs of its subordinate networks.

The mapped cost option converts the units of cost and features in each subordinate network into the units of cost and features for the present network.

The mapped cost offer is a particularly powerful mechanism, as it allows a
20 network to express a very precise and up-to-date cost model (that is, one that reflects details of its subordinate networks) for zero operator cost. In general, mapped cost is a very effective way to transferring rational decision making capability from subordinate networks to superior networks. This is necessary because the subordinate networks, close to the equipment, understand the
25 equipment-related intricacies, while the superior networks, close to the service layer, have a sufficiently broad view to perform network-wide optimum resource allocation.

The cost model 68 of the embodiment, which uses a data structure in the form of a traversable graph of cost nodes, includes three major aspects. Each aspect
30 is designed to solve cost-related problems in the different stages of the management application development. The aspects of a preferred modelling process are:

- Cost graph creation - a cost graph notation is defined. This notation can be used during the design stage to assist system integrators and network engineers to analyse the cost model at different network levels.
 - Cost model specification - during specification stage, the core software can be used to translate the cost graph representation of the network cost model to the format that can be loaded into a connection manager system.
 - Route selection algorithm - based on the internal representation of the cost model, the route selection algorithm and the cost-based routing algorithm are used for path creation.
- Here the term route means a set of sub-paths that together implement a path between terminations at two selected locations in the network.

Cost Graph

A cost graph is a graphical representation of a cost model. In some cases, a cost model can be represented by a single cost graph; in some other cases, a number of disconnected cost graphs are needed to represent a single cost model. In order to understand the cost model and how it may be used to assist the selection of a path route, an example network is used. The physical architecture of the example network is illustrated in FIG.4.

The physical network contains a number of access devices, such as multiplexers, marked as A1 to A4; a number of edge switches marked as E1 to E3 and two core switches, C1 and C2. These physical components form two logic groups: an access domain, which provides the customer access front end to the network, and a core domain, which provides the communication back bone of the network. Each access device has a number of customer termination points, such as A to H, and is linked to an edge switch. An access device cannot switch, that is, no path can be created between two terminations connected to the same access device without going out to an edge switch. In the above example network, all possible paths contain one of the following sub-paths: $A_i-E_j-A_k$, $A_i-E_j-E_k-A_l$, $A_i-E_j-C_k-E_l-A_m$, $A_i-E_j-C_k-C_l-E_m-A_n$. ($i, j, k, l, m, n = 1$ to 4). Using the connection model discussed earlier, the network can be modelled as a cross-domain network containing two domain sub-networks, an access domain sub-network and a core domain sub-network. Each sub-network contains a number of items of equipment as

its sub-networks. A view of the connection model for the network is illustrated in FIG. 5, and it will be appreciated that this network could itself be a sub-network of the larger network illustrated in FIG. 1.

The cost model of each network can be represented using a cost graph or a set of cost graphs. A cost graph contains the following three basic elements, as follows:

“Cost node” - the basic element in a cost graph. Each cost node has a name and the following information associated with the cost node:

- a set of features this cost node supports, derived from the connection model;
- the cost of using these features; and
- the delay in implementing these features.

“Termination” - a special node in the cost graph indicating the potential starting and ending point of a path. It could be a single termination, although typically it is a termination group.

“Edge” - a line between a termination point and a cost node or between two cost nodes.

An important aspect of constructing a cost graph is to identify a set of cost nodes for the network. Potentially, any network resource or abstract of such resource can be a cost node. Example network resources include network equipment, connections, sub-networks, and even the network itself. Manually building a cost graph to represent a cost model of an entire network is a complex task. Therefore the connection manager allows the cost model of a network to be an aggregation of the cost models of the sub-networks. Hence, the cost model of a network can be composed from a set of cost models of sub-networks or even a cost model of a group of network equipment, with negligible configuration effort. In the example network shown in FIG. 4, a simple cost model can be constructed for each piece of network equipment, such as access devices and switches.

FIG. 6 shows the multiplexer A1 and its corresponding cost graph. On the customer side of A1, there two termination points, A and B. Both A and B can be grouped as a termination group. The access device does not support local switching, so there are is no direct connection between A and B. On the network

side, A1 has a termination a connected to an edge switch in the core domain. Multiplexer A1 can be modeled as a single cost node with two terminations, TG1 (termination group 1 containing terminations A and B) and a. Turning to consider a multiplexer with reference to FIG. 7. In general, an m-to-n multiplexer has one
5 customer side containing m terminations and one core side containing n terminations. The terminations on each side can be grouped into one group. Such a multiplexer can be represented as a single cost node with two termination groups as shown in FIG. 7B.

The cost model for an edge switch and a core switch is similar to the one for
10 an access device, except that both the edge switch and the core switch support local switching. That is a path can be created from one termination point to itself (it may in fact go through different virtual channels or virtual paths). In the case of an edge switch E1 as shown in FIG. 8A, paths m-E1-m, n-E1-n, m-E1-n, m-E1-q and n-E1-q can be created. To represent this, double edges to the same termination should be
15 used. The cost graph of the edge switch E1 can be represented as shown in FIG. 8B.

Because the physical capabilities of a core switch are similar to that of the edge switch E1, the cost model of a core switch should be similar to the cost model of the edge switch E1. For example, core switch C1 is capable of performing local switching. To represent this, duplicated terminations should be used as shown in
20 FIG. 9. However, a business rule may specify that based on the network architecture given in Figure 1, the local switching capability supported by core switches does not add any value to the path creation, and hence should be ignored during cost modelling. For example, because edge switch E1 supports local switching, a path A1-E1-A2 can be created. This basically eliminates the requirement of having a
25 path A1-E1-C1-E1-A1. To enforce this business rule, the cost model of core switch C1 should really be modelled shown in FIG. 10. This is an example of how, in the cost model, a business rule can override physical capability in the network.

Cost Model Aggregation

Generally a physical network contains a number of sub-networks and for
30 mapped cost models, the connection manager performs the aggregation. In some embodiments, the cost model may be partially mapped as required. If each sub-network's cost model contains only a single cost graph and a link between a

termination of a cost graph to another termination of another cost graph is specified by a system integrator, then connection manager does the aggregation by replacing the terminations and associated edges with a single edge. For example, if a link is specified between the termination q of cost graph E1 and the termination r of cost graph C1, as shown in FIG. 11. The terminations involved in the link q and r become internal terminations (sometimes also referred to as intermediate terminations) of the current network. These terminations will be required by the creation of sub-paths during routing.

If the connections between different sub-networks bear significant cost, then a cost can be specified for the links. In the above example, if the connection between E1 and C1 bears a cost, a new cost node CN_L1 is introduced when aggregating these two cost models, as shown in FIG. 12. If a link involves duplicated terminations (e.g. in the case of support local switching), then the other cost graph (the one without duplicated terminations) should be duplicated and each linked to one of the duplicated terminations. For example, a link between termination a of cost graph for A1 (see Figure 6B) and termination m in cost graph for E1 (see Figure 8B) will lead to the aggregated cost graph illustrated by FIG. 13.

Applying these aggregation techniques to all cost models in the core domain, the domain cost model shown in FIG. 14 can be obtained. Whilst FIG. 15 illustrates the cost model for the network obtained, after accounting for duplicated terminations, for the cross domain corresponding to the physical network shown in FIG. 4.

Cost Based Route Selection

The method for route selection involves creating an aggregate cost graph of the relevant sub-networks, as described above, and keeping a record of which sub-network is responsible for each cost node. The second part of the method involves finding the lowest-cost of path through the cost nodes between terminations available at the desired locations. A system for allowing exclusion of certain types of sub-networks may, in some cases, be used to "filter" the cost model prior to using the route selection method of the embodiment.

A routing method which may be used to select a route with the lowest cost will now be described. During the selection process, the feature set associated with each cost node provides another level of filtering. If the required features are not

supported by a sub-network, then any paths involving that sub-network are not selected. In the following discussion, in order to describe the routing method clearly, a cost graph is re-shaped according to the starting location (or termination group) specified in a path creation request. For example, to create a cross domain path from termination point E to H as indicated in Figure 4, the cross domain cost graph in FIG. 15 can be re-shaped as a tree structure with the starting termination group as the root, and the ending termination group and other terminations as the leaves. The re-shaped cost graph is shown in FIG. 16. Such shaped cost graph shows all the possible routes starting with the given termination. If multiple routes from the starting termination to the ending termination exist, then the ending termination will appear more than once.

The diagram in FIG. 17 illustrates one form of the path selection method. Starting from C1, which is the cost node directly linked to the starting termination A, a first wave is generated. The wave contains all the cost nodes that support the required feature and are directly connected to C1. Three cost nodes involved in the frontage of the first wave are C2, C3 and C4. From the starting termination A to each frontage cost node forms a candidate route. By adding the current sub-total cost of each candidate route, a lowest-cost candidate route (from A to C2) is selected. Progress will only be made with the currently selected route by pushing the wave one step further to form a second wave. The frontage cost nodes of the second wave include two groups:

- all frontage cost nodes of the unselected routes in the last wave, e.g. C3 and C4; and
- all cost nodes directly connected to the selected cost node in last wave, e.g. C5 and C6.

Here it is assumed that both C3 and C4 support the required feature.

The above process can be repeated until the paths from A to B with the lowest cost are selected. In the example the selected route is A-C1-C2-C6-C10-H. The cost of the selected route is 7, which cost is lower than the current sub-total of any other single candidate route. Applying the method for route selection from E to H in FIG. 16, a route from E-CN_A3-CN_E2- CN_E3-CN_A4-H will be selected as follows with reference to FIG. 18. Apart from the feature parameter, that may

affect the route selection, another parameter "delay" may also affect the selection of a route. The routing algorithm can also be optionally arranged to reject paths having delays greater than a required maximum delay.

Once a route is selected using the cost model, it provides a reference of how
5 the required connection can be created in the physical network. If the selected route only involves one sub-network the connection can be created over the sub-network. If the route involves more than one sub-network, then a number of paths need to be created over the relevant sub-networks. In order to make the necessary connections, the current network must find the intermediate terminations at the boundary of each
10 sub-network. These terminations are those used to form links, as discussed above in relation to FIG. 11.

It will be appreciated that implementations of the cost model, other than a selection method that uses static data in nodes on a traversible graph as described above in relation to the preferred embodiment, are possible. In general terms, the
15 selection method of the embodiment is one implementation of a cost model wherein a delegate offers a data structure that is capable of representing complex or subtle cost predictions when interpreted by a method pre-agreed by the delegate and delegator. Though such data structures are complex, they are not general purpose, in the sense of being Turing machines. This means that there will always be some
20 cost predicates that cannot be conveniently represented in the model.

An alternate approach is to pass a piece of data that is the program for a Turing machine. The delegator and delegate must still agree of the semantic of the data (that is, the implementation of the Turing machine). However there will no longer be intrinsic limitations of the ability to represent any cost model. For
25 example, it is unlikely that a data structure approach could model a cost prediction that involves the calculation of B-spline interpolation (unless the data structure designer foresaw that need). The Turing machine approach does not suffer such a limitation. A practical implementation of the Turing machine approach is to agree on an implementation that is well understood in the industry. One such example is
30 to use a JavaTM Virtual Machine implementation, and the cost model is then transferred as a sequence of JavaTM byte codes.

The cost model allows the connection manager to expose or publish a comprehensive estimate of what a path between two locations will cost, without the

client having to make a vast number of queries about the cost of each possible choice. It is the service provider's or network owner's choice as to how comprehensive a cost model is provided. They may publish a detailed cost model without exposing the underlying structure of the network.

5 By automating the routing and configuration of connections across complex networks, the connection manager substantially reduces the need for manual management at the network and element levels. Connections can be provisioned in real time and the connection manager will scale to process increasing volumes of new connections as broadband communications networks grow.

10 The object oriented approach to modeling aspects of the network in the connection manager, wherein the abstract connection model is differentiated from the connection model instantiations result in a high degree of reuse of clients and servers. This approach also allows for, but does not enforce, very flexible client and server implementations, which can match a rapidly changing business scenario.

15 Throughout the specification the aim has been to describe the preferred embodiments of the invention without limiting the invention to any one embodiment or specific collection of features.

CLAIMS

1. A connection manager for selecting paths, from a plurality of paths available from service providers in a communications network, to route broadband traffic in the network, wherein the connection manager includes:
- 5 (a) a connection model indicating functional features supported by each path in the network and locations of terminations for respective paths;
- (b) a cost model associated with the connection model that exposes to clients the cost of using the functional features for each path; and
- 10 (c) processing means, operated in response to a client requirement for a connection with desired features between two locations in the network, to -
- (i) identify, from the connection model in light of the desired features, suitable candidate paths for routing communications traffic between the two locations and
- 15 (ii) determine, from the candidate paths and on the basis of cost exposed by the cost model, an optimal selection of paths connecting said locations.
2. The connection manager as claimed in claim 1 wherein the functional features indicated by the connection model include one or more of the following:
- 20 (i) communications protocol;
- (ii) transmission rate;
- (iii) availability of the path; and
- (iv) average error rate.
- 25 3. The connection manager as claimed in either claim 1 or claim 2 wherein the cost exposed by the cost model reflects the resources required to implement a path having a particular set of features.
- 30 4. The connection manager as claimed in any one of claims 1 to 3 wherein the path cost is determined in accordance with one or more of:
- (i) number of network elements involved in the path;

- (ii) reduction in network capacity experienced in implementing the path; and
- (iii) funds required to implement the path.

5 5. The connection manager as claimed in any one of claims 1 to 4 wherein the cost model represents path cost as a data structure which is interpreted by the processing means.

10 6. The connection manager as claimed in claim 5 wherein the data structure comprises a graph of cost nodes and each node specifies the cost of particular features or sets of features for respective paths.

15 7. The connection manager as claimed in claim 6 wherein the cost nodes in the graph may be either internal for representing links between internal terminations in the connection model or external for the terminations at said predetermined locations.

8. The connection manager as claimed in any one of claims 1 to 4 wherein the cost model represents path cost as code which is executed by the processing means.

20 9. The connection manager as claimed in claim 8 wherein the processing means for executing the code is an implementation of a Turing machine.

25 10. The connection manager as claimed in any one of claims 1 to 9 wherein the cost model further exposes the delay in implementing functional features supported by the path.

30 11. The connection manager as claimed in claim 10 wherein the client requirement for a connection includes a desired minimum delay which is utilised as a further basis for determining the optimal selection of paths.

12. The connection manager as claimed in any one of the preceding claims wherein individual terminations at the same location that have common attributes are represented as termination groups.

13. A connection manager for selecting paths from a plurality of paths available from service providers in a communications network to route broadband traffic in the network, wherein the connection manager includes:

- 5 (a) a cost model provided by the service provider that exposes to clients the cost of using each path; and
- (b) processing means, operated in response to a client requirement for a connection involving a plurality of terminations in the network, to -
- 10 (i) identify candidate paths for routing communications traffic amongst said plurality of terminations and
- (ii) determine, from the candidate paths and on the basis of cost exposed by the cost model, a least cost selection of paths connecting said terminations.

15 14. The connection manager as claimed in claim 13 wherein the cost model also exposes delay in the service provider making a path available.

15. The connection manager as claimed in either claim 13 or claim 14 wherein available paths include paths pre-existing in the network.

20

16. The connection manager as claimed in either claim 13 or 14 wherein available paths include paths that can be created by the service provider.

17. The connection manager as claimed in any one of claims 13 to 16 wherein
25 the cost model exposes usage cost depending on the functional features required of each path.

18. The connection manager as claimed in any one of claims 13 to 16 wherein
30 the cost exposed by the cost model reflects the resources required to implement a path having a particular set of features.

19. The connection manager as claimed in any one of claims 13 to 18 wherein the path cost is determined in accordance with one or more of:

- (i) number of network elements involved in the path;
- (ii) reduction in network capacity experienced in implementing the path;
and
- (iii) funds required to implement the path.

5

20. The connection manager as claimed in any one of claims 13 to 19 wherein the cost model represents path cost as a data structure which is interpreted by the processing means.

10 21. The connection manager as claimed in any one of claims 13 to 20 wherein the cost model represents path cost as code which is executed by the processing means.

22. The connection manager as claimed in any one of claims 13 to 21 wherein a
15 cost model is transferred from each service provider.

23. The connection manager as claimed in any one of claims 13 to 22 wherein the client is a superior connection manager and a superior cost model is constructed from an aggregate of cost models transferred by subordinate connection managers.

20

24. A selection method for selecting paths, from a plurality of paths available from service providers in a communications network, to route broadband traffic in the network, including the steps of:

- (a) creating a connection model that indicates functional features supported by
25 each path in the network and locations of terminations for respective paths;
- (b) creating a cost model associated with the connection model that exposes to clients the cost of using the functional features for each path; and
- (c) processing a client requirement for a connection with desired features between two locations in the network by -
30 (i) identifying, from the connection model in light of the desired features, suitable candidate paths for routing communications traffic between the two locations and

- (ii) determining, from the candidate paths and on the basis of the cost exposed by the service provider, an optimal selection of paths connecting said locations.

5 25. The selection method of claim 24 wherein the step of creating the connection model reflects attributes of network elements deployed by each service provider.

10 26. A method of managing selection of paths from a plurality of paths available from service providers in a communications network to route broadband traffic in the network, said method including the steps of:

- (a) creating a cost model whereby a service provider exposes to clients the cost of using each path;
- (b) processing a client requirement for a connection involving a plurality of terminations by
 - 15 (i) identifying candidate paths for routing communications traffic amongst said plurality of terminations and
 - (ii) determining, from the candidate paths and on the basis of cost exposed by the cost model, a least cost selection of paths connecting
 - 20 said terminations.

27. The method of managing selection as claimed in claim 26 wherein the cost model is transferred from the service provider.

25 28. The method of managing route selection as claimed in either claim 26 or claim 27, wherein the client is a superior connection manager and a superior cost model is constructed from an aggregate of cost models transferred from subordinate connection managers.

1 / 15

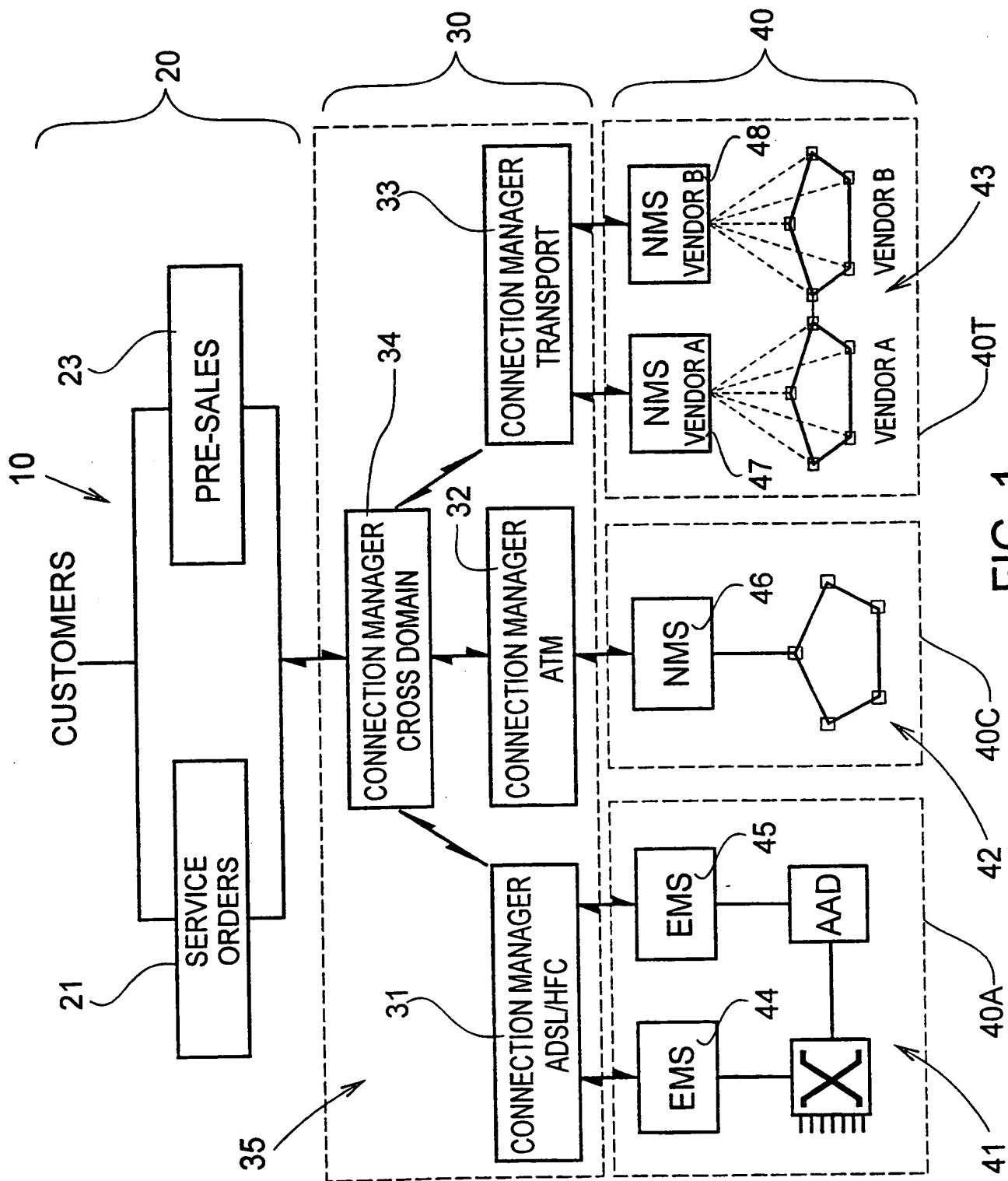


FIG. 1

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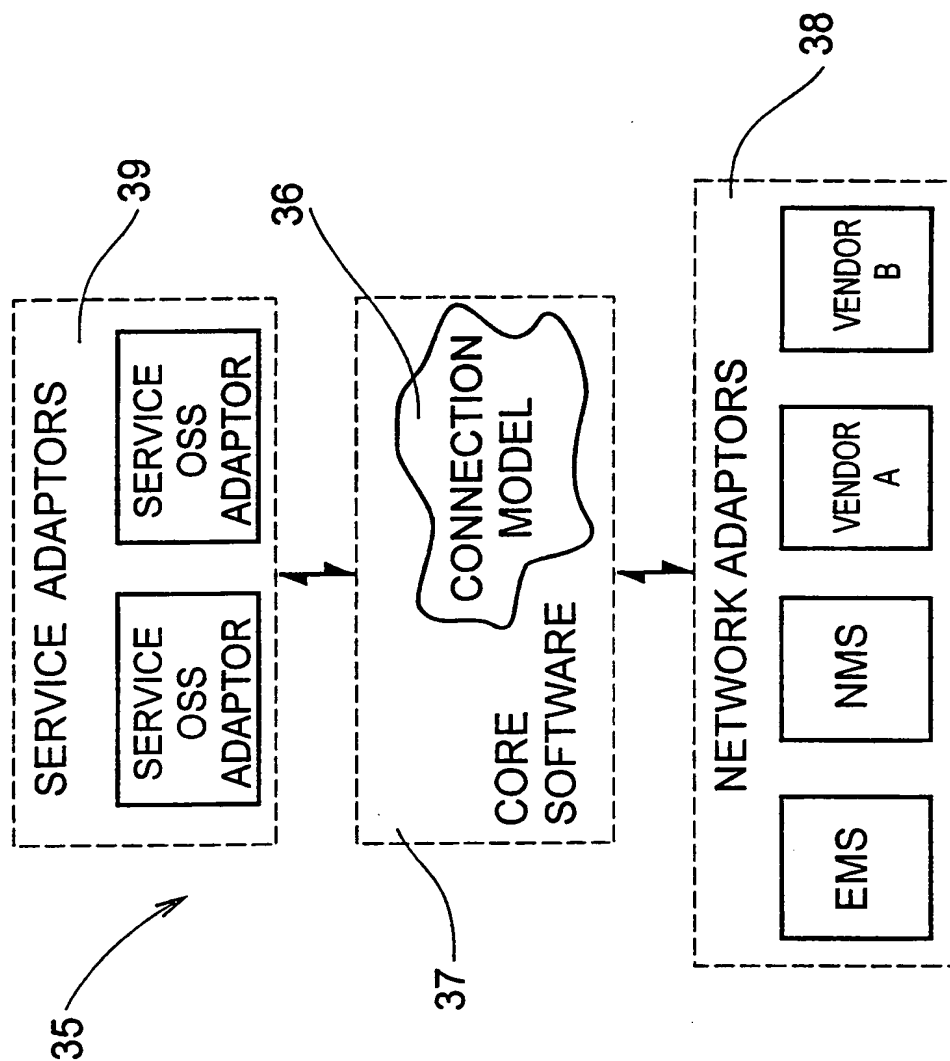


FIG. 2A

3 / 15

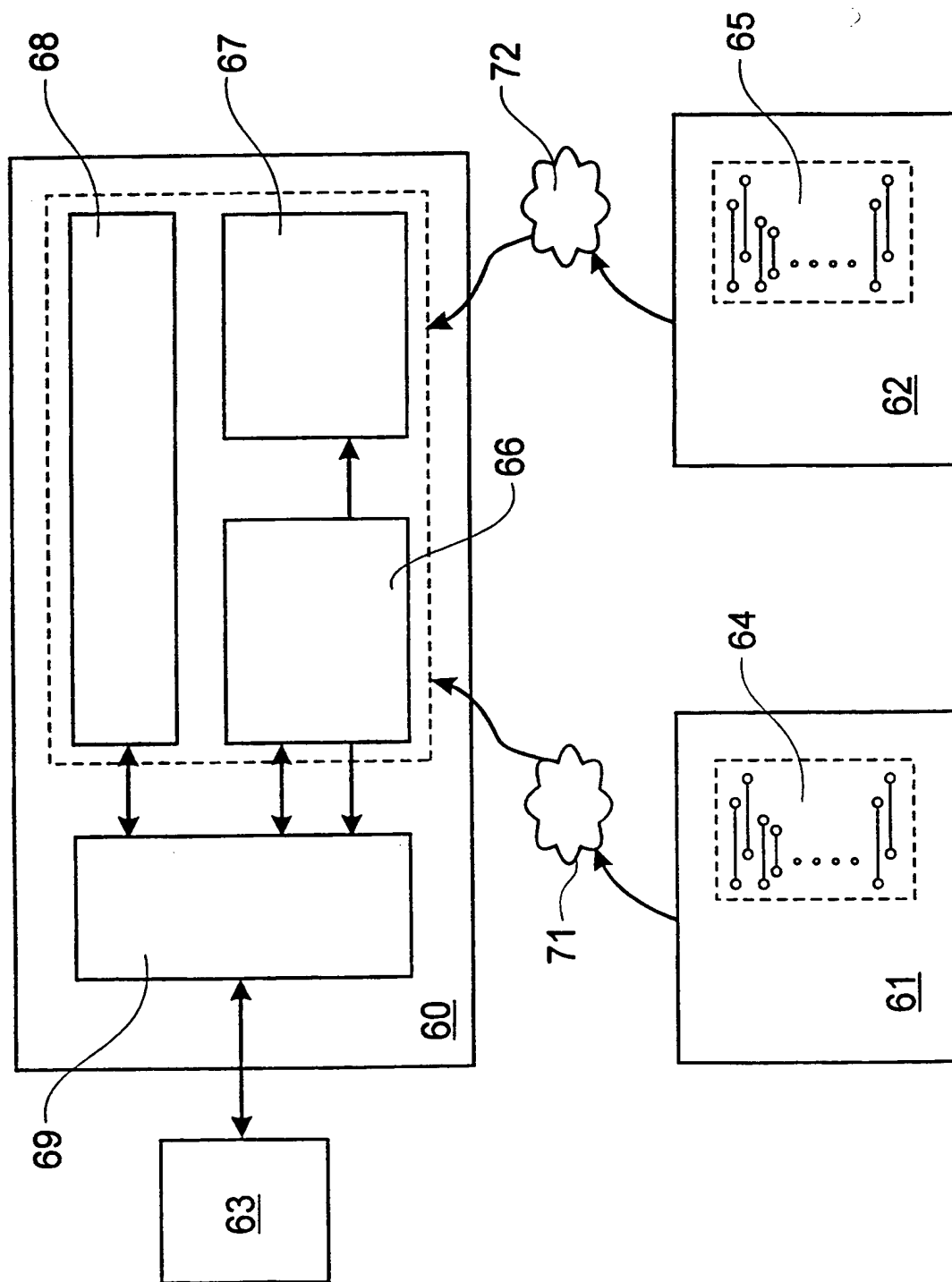


FIG. 2B

4 / 15

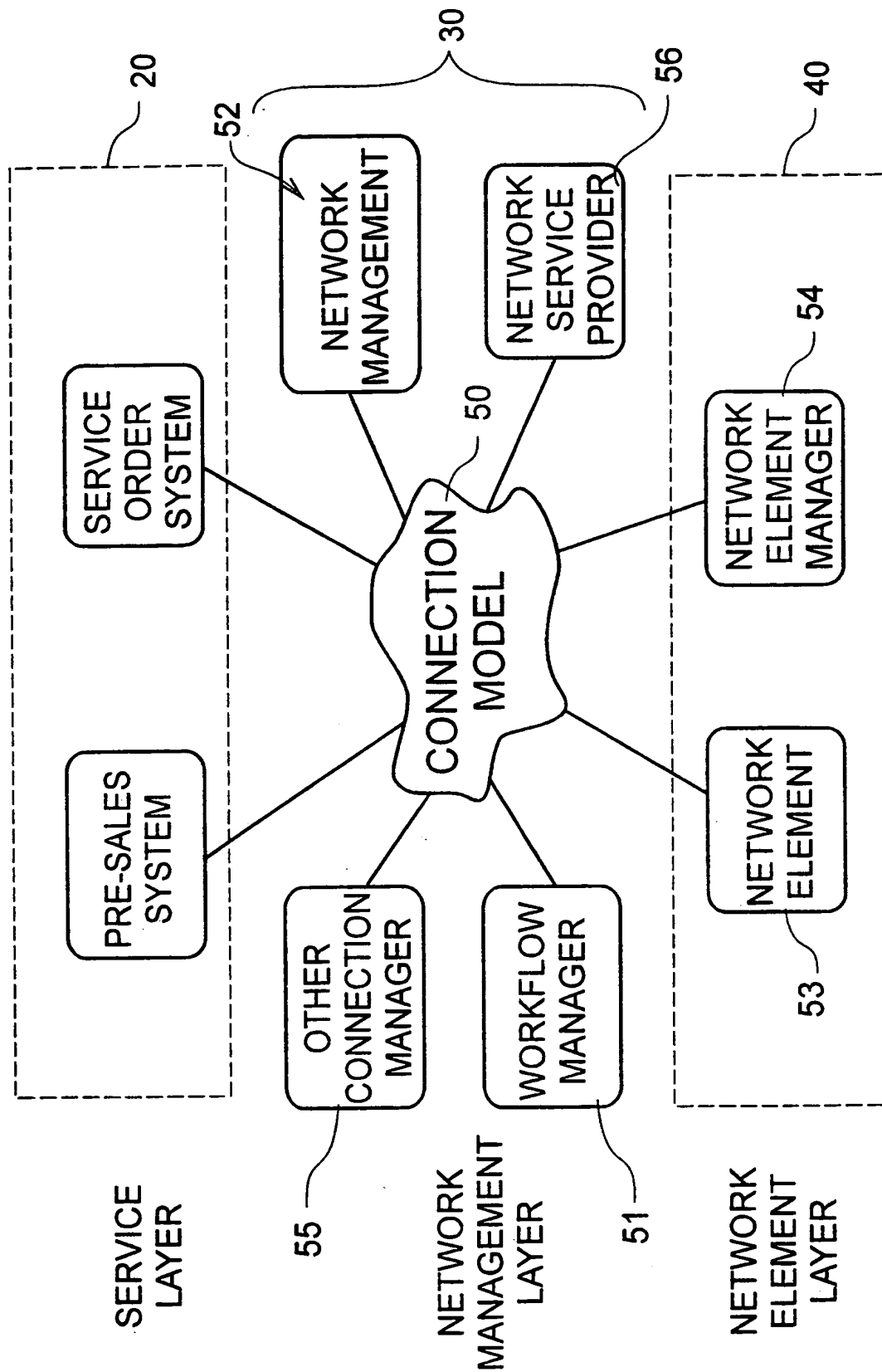


FIG. 3

5 / 15

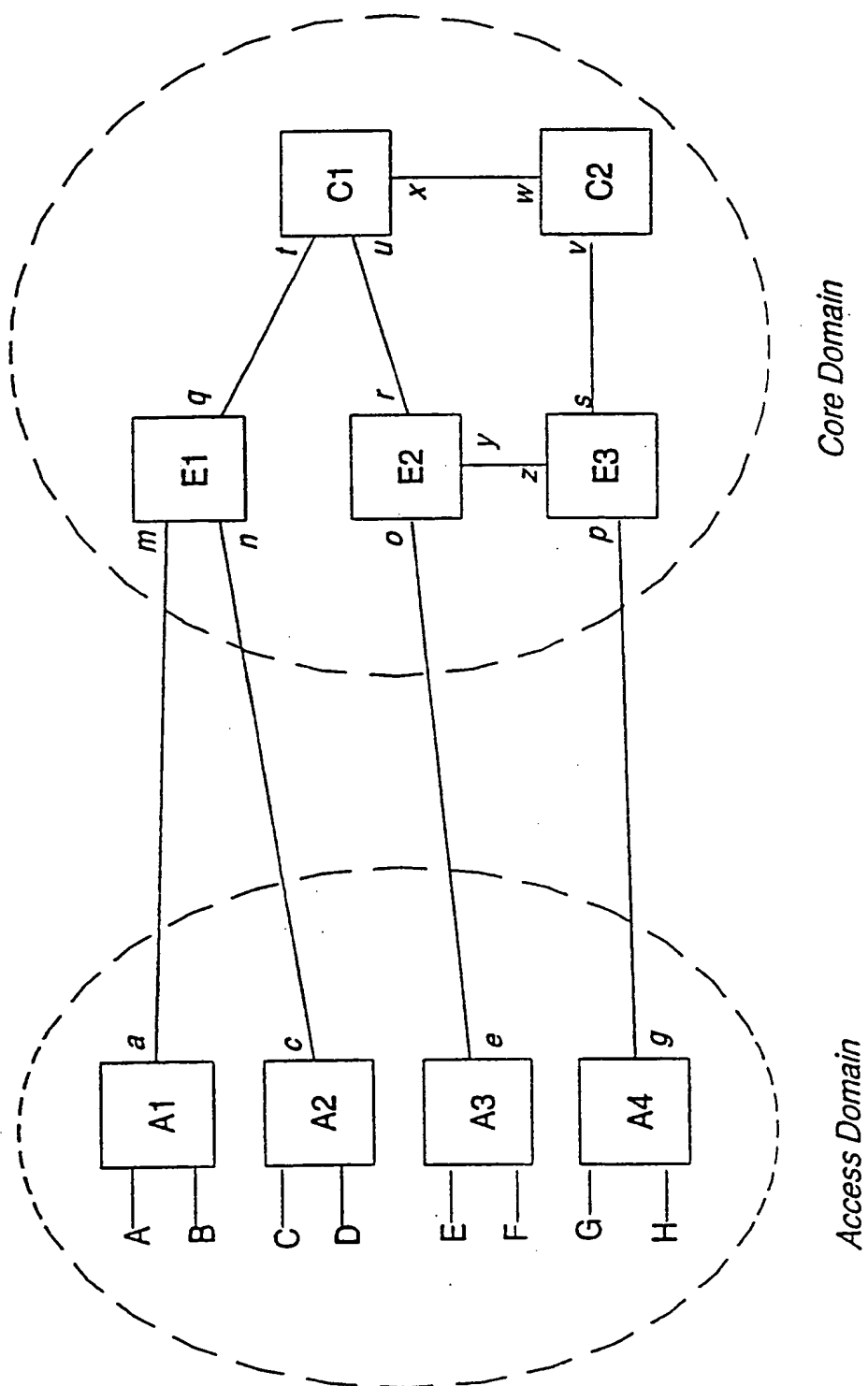


FIG. 4

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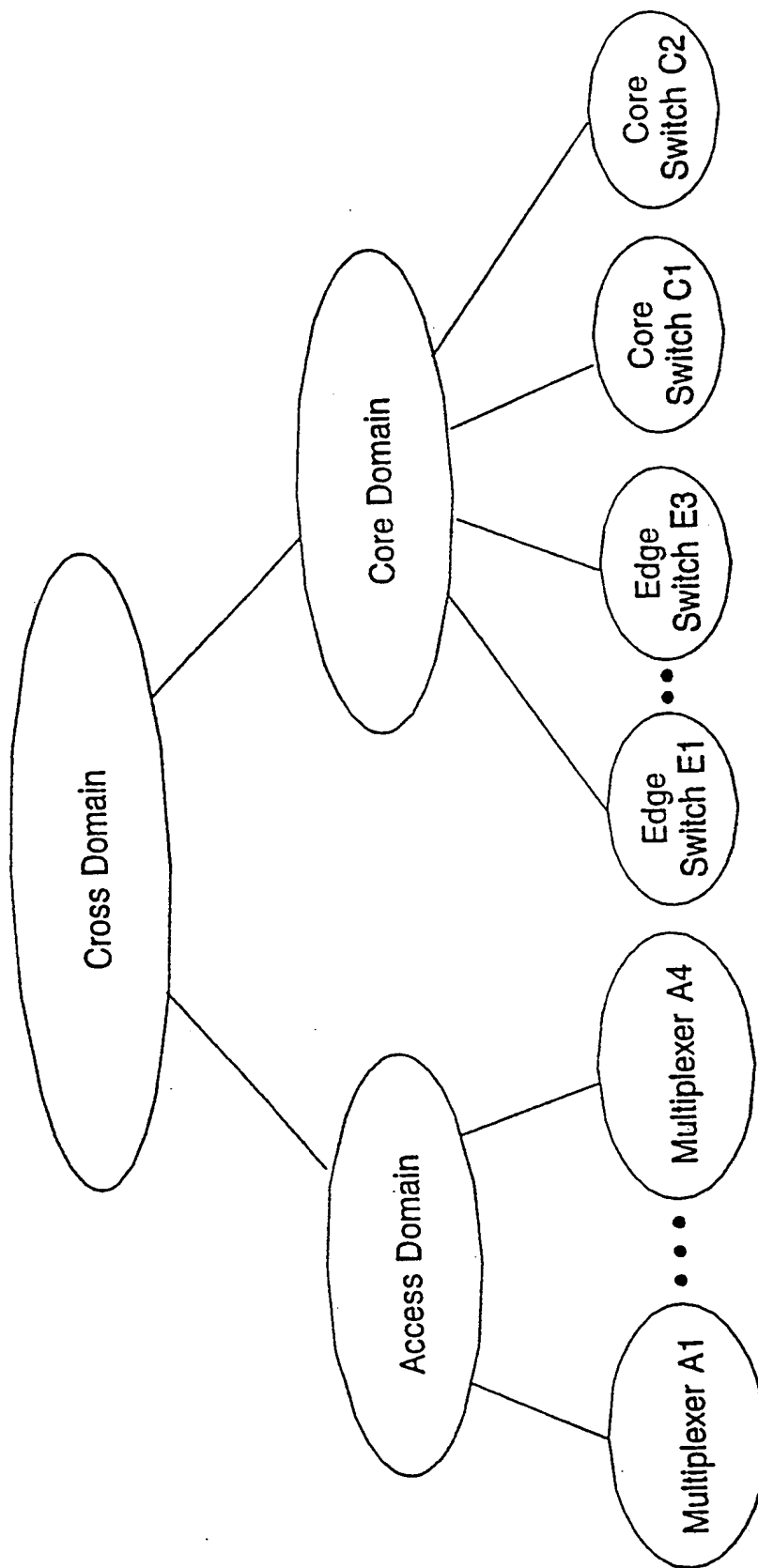


FIG. 5

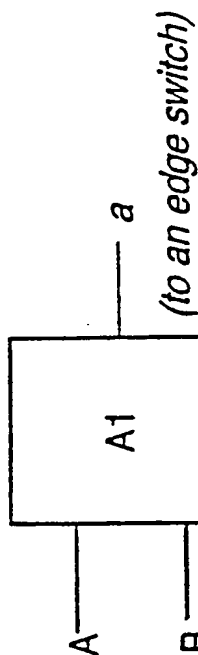


FIG. 6A

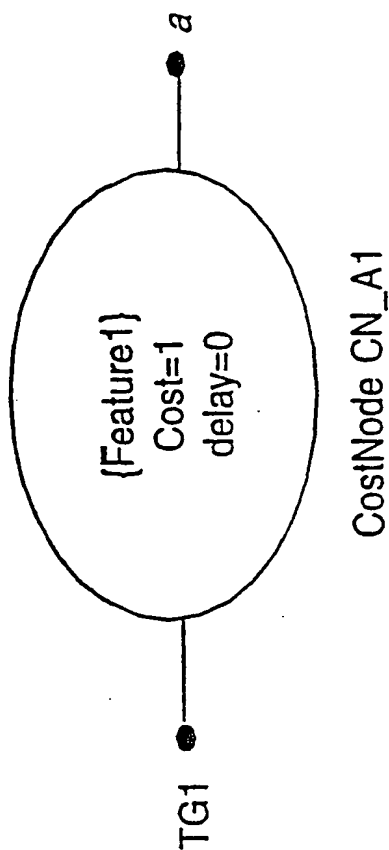


FIG. 6B

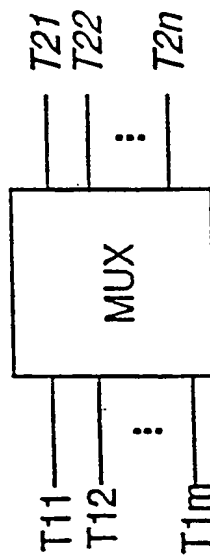


FIG. 7A

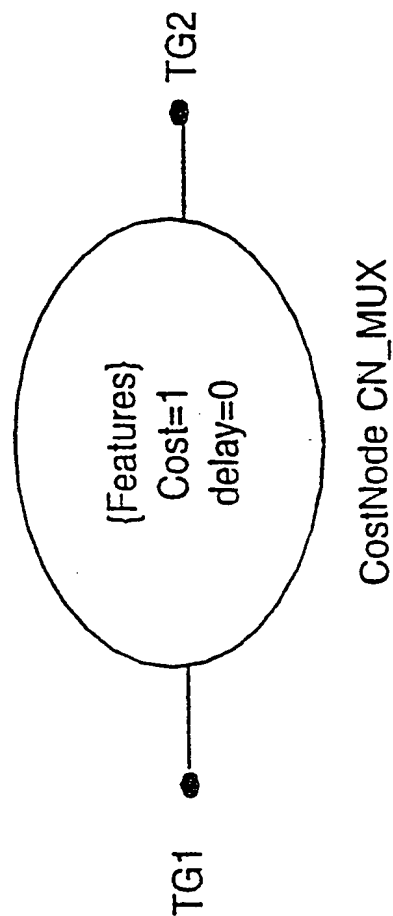


FIG. 7B

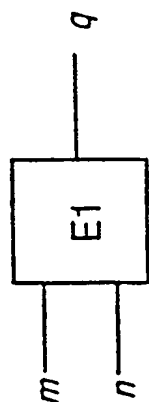


FIG. 8A

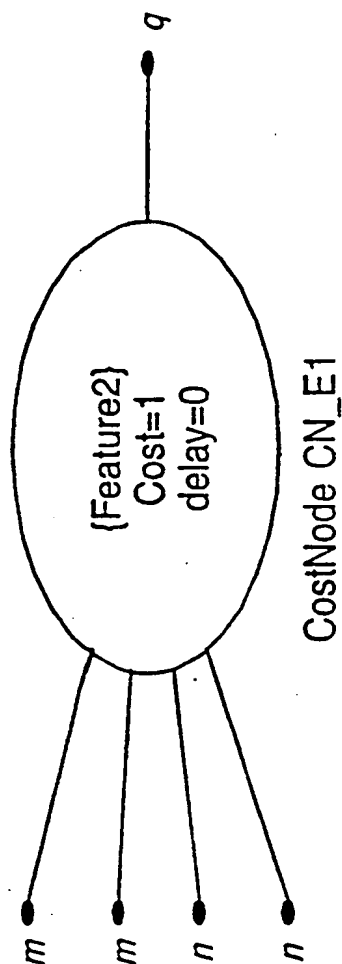


FIG. 8B

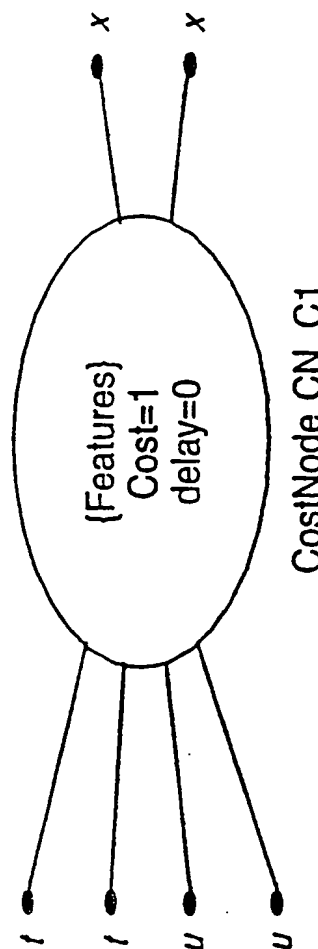
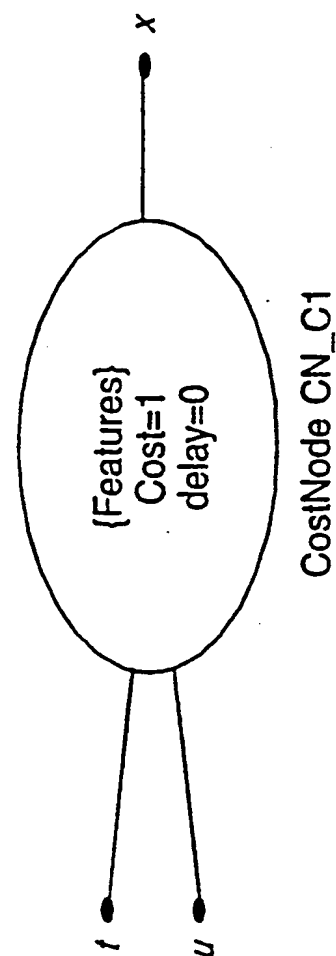


FIG. 9

FIG. 10



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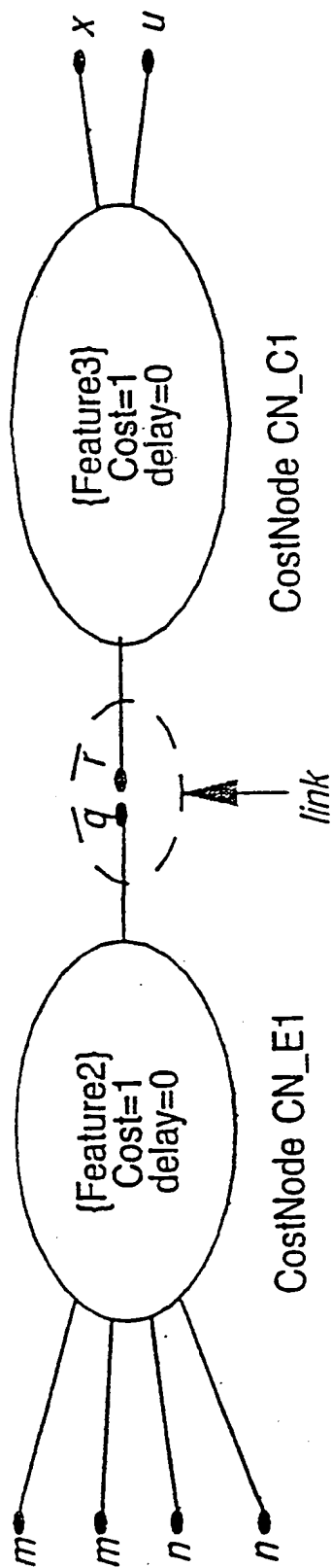


FIG. 11

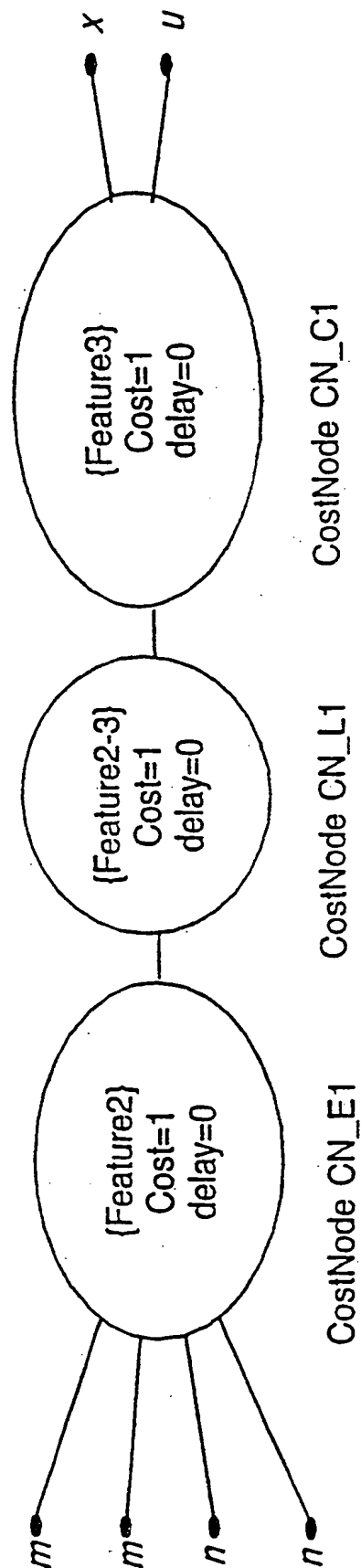


FIG. 12

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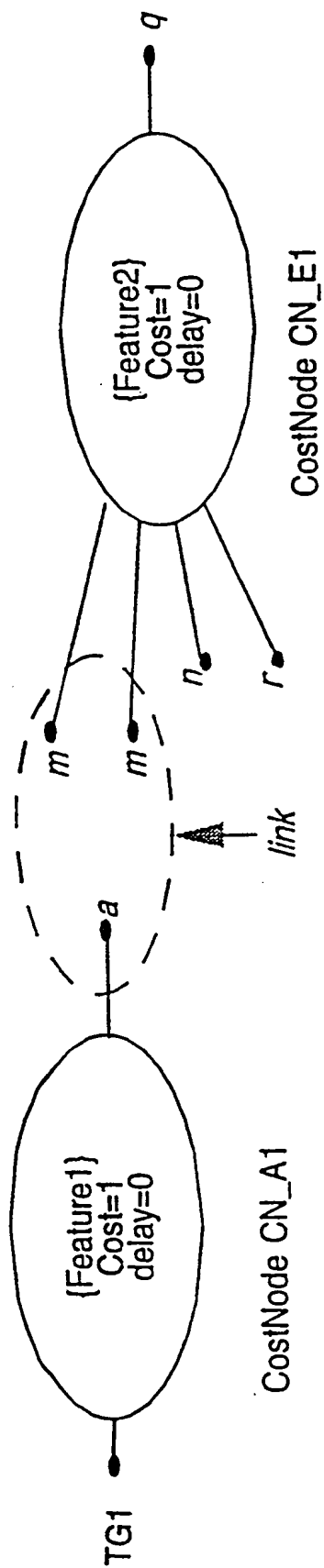


FIG. 13A

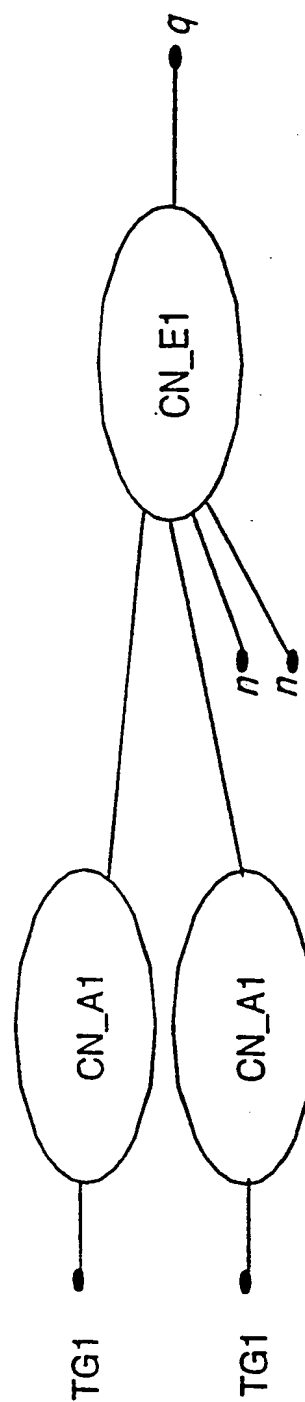


FIG. 13B

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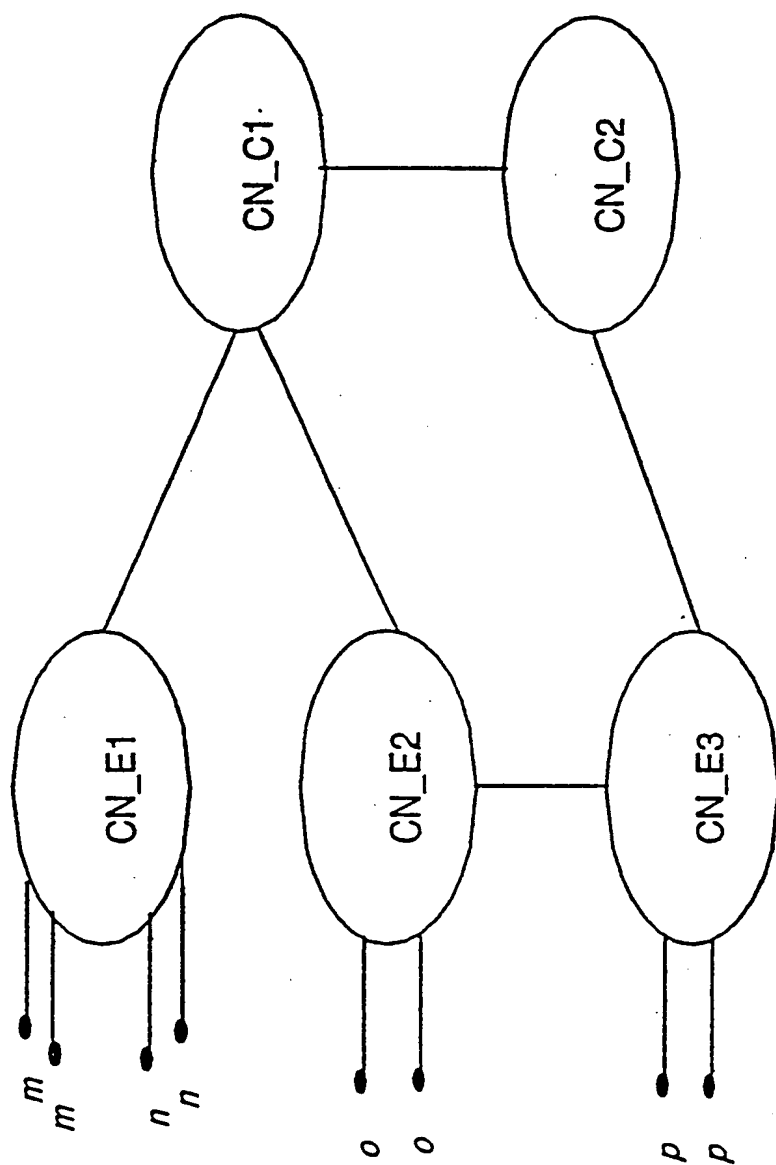


FIG. 14

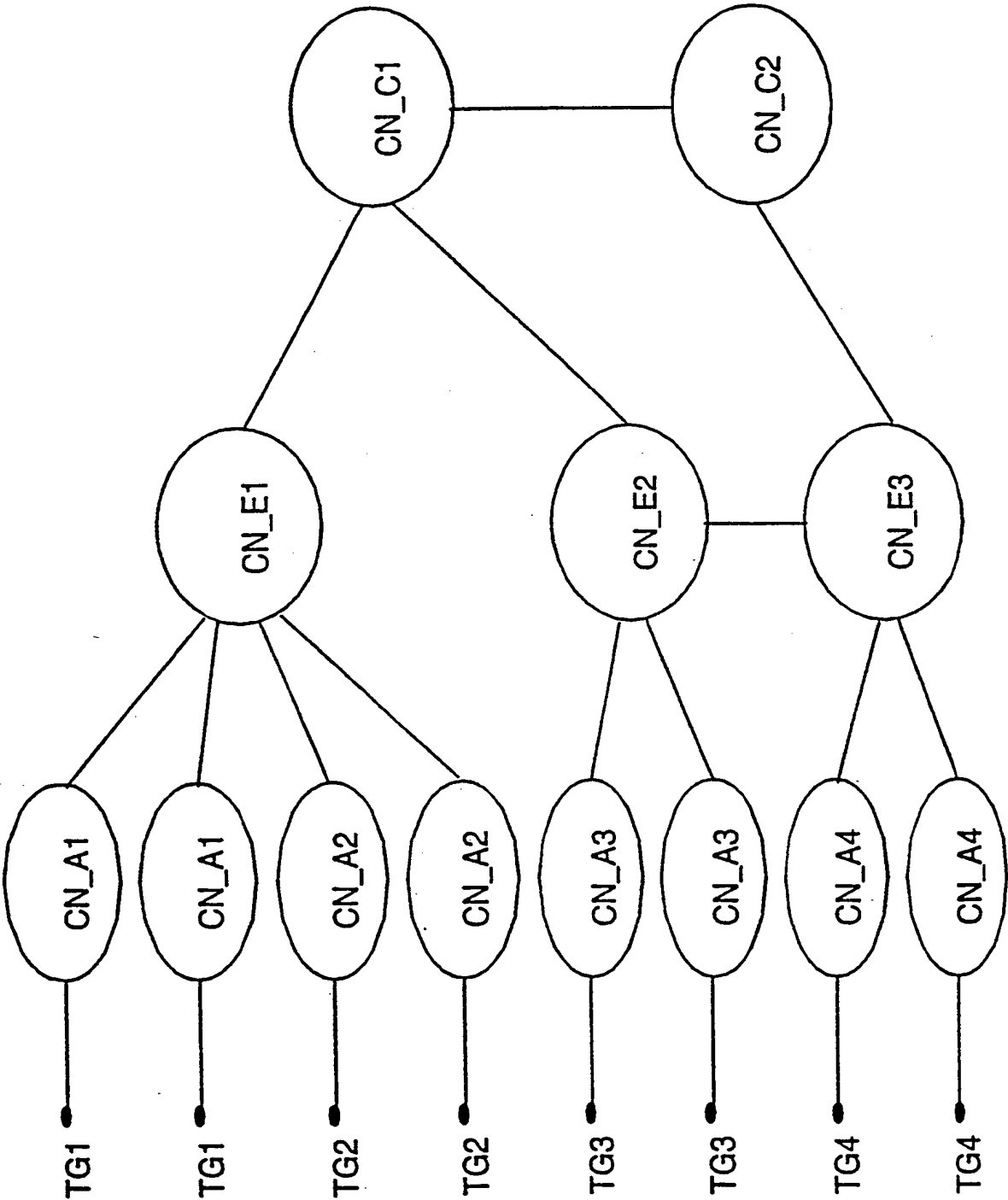


FIG. 15

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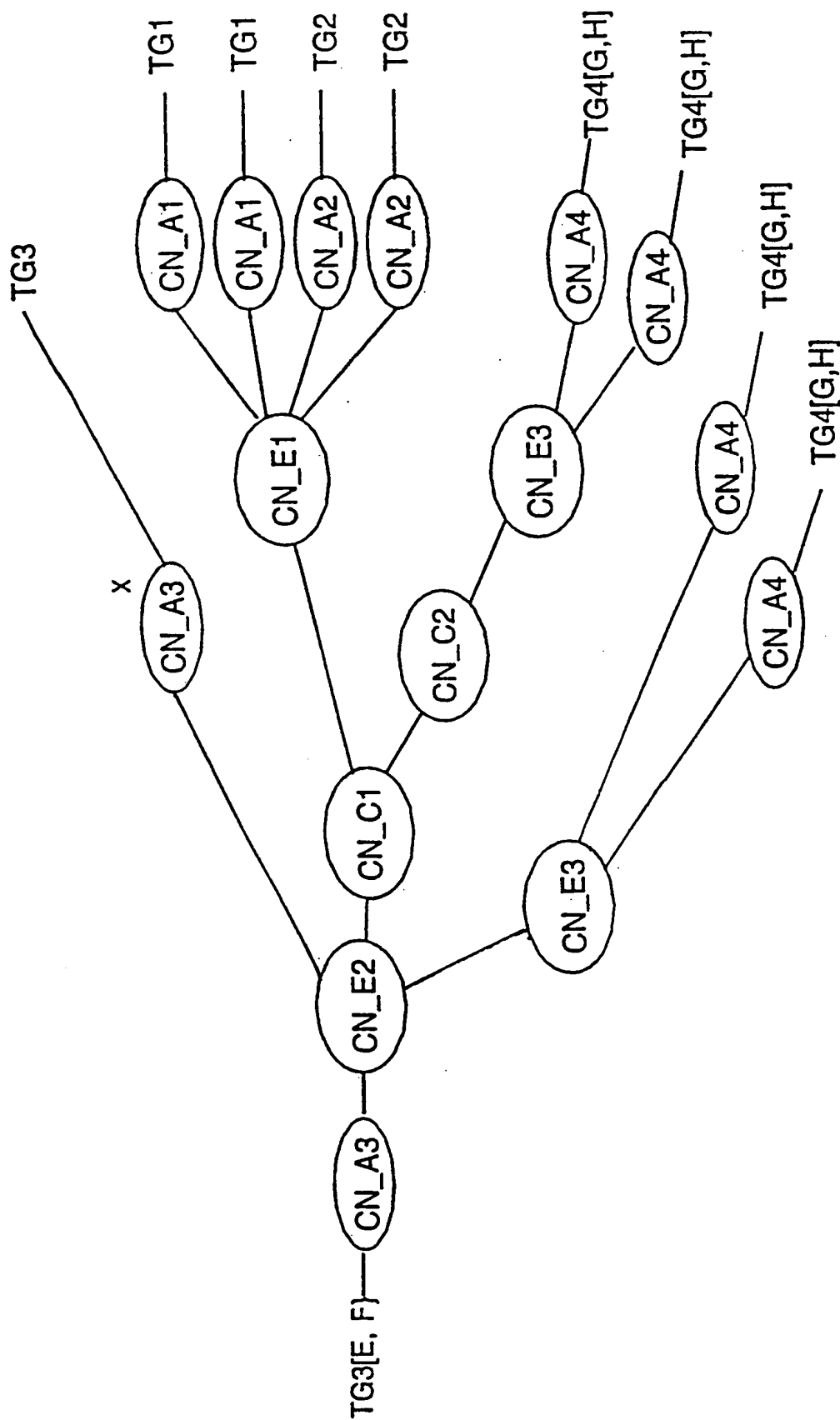


FIG. 16

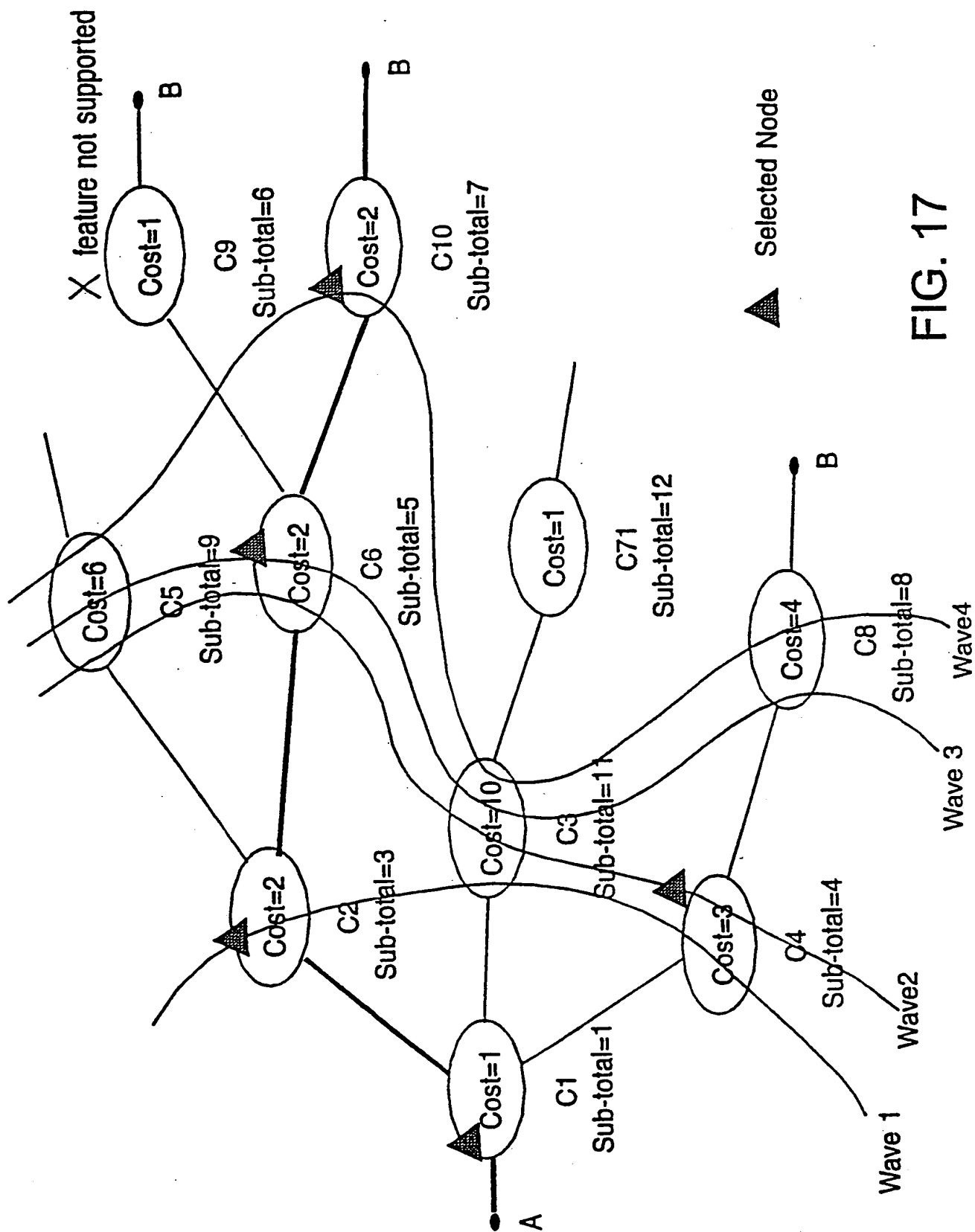


FIG. 17

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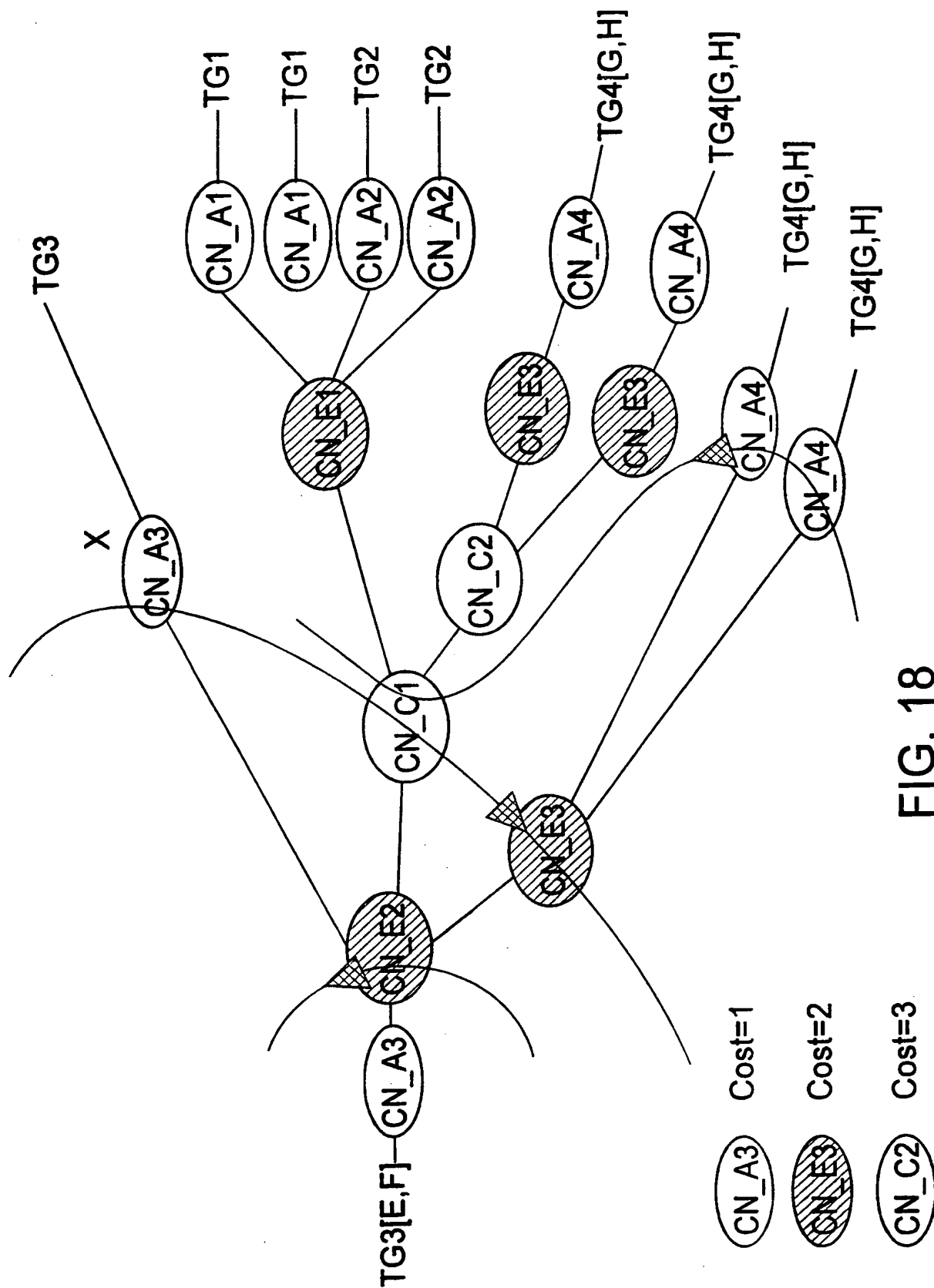


FIG. 18

INTERNATIONAL SEARCH REPORT

International application No.
PCT/AU 99/00873

A. CLASSIFICATION OF SUBJECT MATTER					
Int Cl ⁶ : H04L 12/66, H04Q 3/00					
According to International Patent Classification (IPC) or to both national classification and IPC					
B. FIELDS SEARCHED					
Minimum documentation searched (classification system followed by classification symbols) IPC ⁶ : INT. CL. (AS ABOVE)					
Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched					
Electronic data base consulted during the international search (name of data base and, where practicable, search terms used) WPAT, INSPEC (connection, manag., cost, route)					
C. DOCUMENTS CONSIDERED TO BE RELEVANT					
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.			
X	WO 99/17506 (Ericsson) 8 April 1999 & NO 974487 - A0 OPI 29-September 1997, Both documents	1, 13, 24, 26			
X Y	WO 94/28683 (British Telecomm.) 8 December 1994 Whole document	1, 13, 24, 26 2 - 7, 12, 15 - 20, 25			
Y	WO 98/21858 (MCI Communications) 22 May 1998 Whole document	1 - 7, 12, 13, 15 - 20, 24 - 26			
<div style="display: flex; justify-content: space-between;"> <input checked="" type="checkbox"/> Further documents are listed in the continuation of Box C <input checked="" type="checkbox"/> See patent family annex </div>					
<table style="width: 100%; border: none;"> <tr> <td style="width: 33%; vertical-align: top;"> <p>* Special categories of cited documents:</p> <p>"A" Document defining the general state of the art which is not considered to be of particular relevance</p> <p>"E" earlier application or patent but published on or after the international filing date</p> <p>"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)</p> <p>"O" document referring to an oral disclosure, use, exhibition or other means</p> <p>"P" document published prior to the international filing date but later than the priority date claimed</p> </td> <td style="width: 33%; vertical-align: top;"> <p>"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention</p> <p>"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone</p> <p>"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art</p> <p>"&" document member of the same patent family</p> </td> <td style="width: 33%;"></td> </tr> </table>			<p>* Special categories of cited documents:</p> <p>"A" Document defining the general state of the art which is not considered to be of particular relevance</p> <p>"E" earlier application or patent but published on or after the international filing date</p> <p>"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)</p> <p>"O" document referring to an oral disclosure, use, exhibition or other means</p> <p>"P" document published prior to the international filing date but later than the priority date claimed</p>	<p>"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention</p> <p>"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone</p> <p>"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art</p> <p>"&" document member of the same patent family</p>	
<p>* Special categories of cited documents:</p> <p>"A" Document defining the general state of the art which is not considered to be of particular relevance</p> <p>"E" earlier application or patent but published on or after the international filing date</p> <p>"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)</p> <p>"O" document referring to an oral disclosure, use, exhibition or other means</p> <p>"P" document published prior to the international filing date but later than the priority date claimed</p>	<p>"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention</p> <p>"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone</p> <p>"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art</p> <p>"&" document member of the same patent family</p>				
Date of the actual completion of the international search 21 October 1999		Date of mailing of the international search report - 5 NOV 1999			
Name and mailing address of the ISA/AU AUSTRALIAN PATENT OFFICE PO BOX 200 WODEN ACT 2606 AUSTRALIA E-mail address: pct@ipaustalia.gov.au Facsimile No.: (02) 6285 3929		Authorized officer DALE E. SIVER Telephone No.: (02) 6283 2196			

INTERNATIONAL SEARCH REPORT

International application No.

PCT/AU 99/00873

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	GB 2299240 (Northern Telecom) 25 September 1996 Whole document	1 - 7, 12, 13, 15 - 20, 24 - 26
X	"On Computing Markov Decision Theory-Based Cost For Routing in Circuit-Switched Broadband Networks" (Kolarov et al.) Journal of Network and Systems Management Vol. 3. No. 4 ; 1995 pp 405 - 426 Whole Document	1, 13, 24, 26
Y		2 - 7, 12, 15 - 20, 25
Y		15 - 19
	"Optimal Expansion of Fiber-Optic Telecommunication Networks in Metropolitan Areas" (Kuehner et al.) Interfaces 23:2 March - April 1993 pp 35 - 48 Abstract, figure 1, 3, tables	

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.
PCT/AU 99/00873

This Annex lists the known "A" publication level patent family members relating to the patent documents cited in the above-mentioned international search report. The Australian Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

Patent Document Cited in Search Report				Patent Family Member			
WO	9917506	AU	90087/98	NO	974487		
WO	9428683	AU	67299/94	AU	94151/98	AU	94153/98
		CA	2159829	CN	1124558	EP	700625
		SG	43106	US	5802502		
WO	9821858	US	5838660				
GB	2299240	EP	815702	US	5943339	WO	9631080

END OF ANNEX

The demand must be filed directly with the competent International Preliminary Examining Authority or, if two or more Authorities are competent with the one chosen by the applicant. The full name or two-letter code of that Authority may be indicated by the applicant on the line below:

IPEA/ AU

09/807338

PCT

CHAPTER II

DEMAND

under Article 31 of the Patent Cooperation Treaty:
The undersigned requests that the international application specified below be the subject of international preliminary examination according to the Patent Cooperation Treaty and hereby elects all eligible States (except where otherwise indicated).

For International Preliminary Examining Authority use only	
Identification of IPEA	Date of receipt of DEMAND
Box No. I IDENTIFICATION OF THE INTERNATIONAL APPLICATION	
Applicant's or agent's file reference 2/7425/PC	
International application No. PCT/AU99/00873	International filing date (day/month/year) 12 October 1999
(Earliest) Priority date (day/month/year) 12 October 1998	
Title of invention MANAGEMENT OF PATH SELECTION IN A COMMUNICATIONS NETWORK	
Box No. II APPLICANT(S)	
Name and address: (Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country.)	
ASTRACON INC 10303 East Dry Creek Road Suite 250 Englewood CO 80112 USA	
Telephone No.: +1.720.895.8500	
Facsimile No.: +1.720.895.8555	
Teleprinter No.:	
State (that is, country) of nationality: USA	State (that is, country) of residence: USA
Name and address: (Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country.)	
ROSE, Ian Alexander 16 Pedley Street Wavell Heights Queensland 4012 Australia	
State (that is, country) of nationality: AUSTRALIA	State (that is, country) of residence: AUSTRALIA
Name and address: (Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country.)	
State (that is, country) of nationality:	State (that is, country) of residence:
<input type="checkbox"/> Further applicants are indicated on a continuation sheet.	

Box No. III AGENT OR COMMON REPRESENTATIVE; OR ADDRESS FOR CORRESPONDENCE

The following person is ☒ agent ☐ common representative
 and ☒ has been appointed earlier and represents the applicant(s) also for international preliminary examination.
☐ is hereby appointed and any earlier appointment of (an) agent(s)/common representative is hereby revoked.
☐ is hereby appointed, specifically for the procedure before the International Preliminary Examining Authority, in addition to the agent(s)/common representative appointed earlier.

Name and address: *(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country.)*

FISHER ADAMS KELLY
 Level 13
 AMP Place
 10 Eagle Street
 Brisbane Queensland 4000
 Australia

Telephone No.:
+61.7.3 229.2655

Facsimile No.:
+61.7.3 221.0597

Teleprinter No.:

☐ Address for correspondence: Mark this check-box where no agent or common representative is/has been appointed and the space above is used instead to indicate a special address to which correspondence should be sent.

Box No. IV BASIS FOR INTERNATIONAL PRELIMINARY EXAMINATION**Statement concerning amendments:***

1. The applicant wishes the international preliminary examination to start on the basis of:

- ☒ the international application as originally filed
- the description ☒ as originally filed
☐ as amended under Article 34
- the claims ☒ as originally filed
☐ as amended under Article 19 (together with any accompanying statement)
☐ as amended under Article 34
- the drawings ☒ as originally filed
☐ as amended under Article 34

2. ☐ The applicant wishes any amendment to the claims under Article 19 to be considered as reversed.
3. ☐ The applicant wishes the start of the international preliminary examination to be postponed until the expiration of 20 months from the priority date unless the International Preliminary Examining Authority receives a copy of any amendments made under Article 19 or a notice from the applicant that he does not wish to make such amendments (Rule 69.1(d)). *(This check-box may be marked only where the time limit under Article 19 has not yet expired.)*

* Where no check-box is marked, international preliminary examination will start on the basis of the international application as originally filed or, where a copy of amendments to the claims under Article 19 and/or amendments of the international application under Article 34 are received by the International Preliminary Examining Authority before it has begun to draw up a written opinion or the international preliminary examination report, as so amended.

Language for the purposes of international preliminary examination: English

- ☒ which is the language in which the international application was filed.
☐ which is the language of a translation furnished for the purposes of international search.
☐ which is the language of publication of the international application.
☐ which is the language of the translation (to be) furnished for the purposes of international preliminary examination.

Box No. V ELECTION OF STATES

The applicant hereby elects all eligible States *(that is, all States which have been designated and which are bound by Chapter II of the PCT)*

excluding the following States which the applicant wishes not to elect:

Box No. VI CHECK LIST

The demand is accompanied by the following elements, in the language referred to in Box No. IV, for the purposes of international preliminary examination:

- | | | |
|--|---|--------|
| 1. translation of international application | : | sheets |
| 2. amendments under Article 34 | : | sheets |
| 3. copy (or, where required, translation) of amendments under Article 19 | : | sheets |
| 4. copy (or, where required, translation) of statement under Article 19 | : | sheets |
| 5. letter | : | sheets |
| 6. other (specify) | : | sheets |

For International Preliminary
Examining Authority use only

received not received

<input type="checkbox"/>	<input type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>

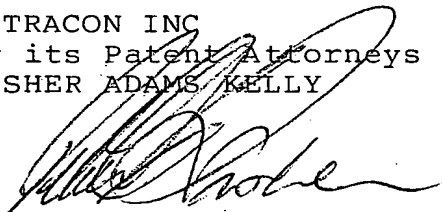
The demand is also accompanied by the item(s) marked below:

- | | |
|--|---|
| 1. <input checked="" type="checkbox"/> fee calculation sheet | 4. <input type="checkbox"/> statement explaining lack of signature |
| 2. <input type="checkbox"/> separate signed power of attorney | 5. <input type="checkbox"/> nucleotide and or amino acid sequence listing in computer readable form |
| 3. <input type="checkbox"/> copy of general power of attorney; reference number, if any: | 6. <input type="checkbox"/> other (specify): |

Box No. VII SIGNATURE OF APPLICANT, AGENT OR COMMON REPRESENTATIVE

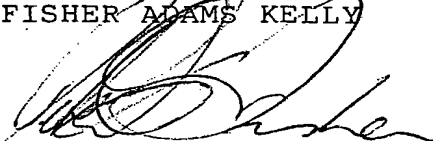
Next to each signature, indicate the name of the person signing and the capacity in which the person signs (if such capacity is not obvious from reading the demand).

ASTRACON INC
By its Patent Attorneys
FISHER ADAMS KELLY



PETER C FISHER
Registered Patent Attorney

IAN ALEXANDER ROSE
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For International Preliminary Examining Authority use only

- Date of actual receipt of DEMAND:
- Adjusted date of receipt of demand due to CORRECTIONS under Rule 60.1(b):
- ☐ The date of receipt of the demand is AFTER the expiration of 19 months from the priority date and item 4 or 5, below, does not apply.
 ☐ The applicant has been informed accordingly.
- ☐ The date of receipt of the demand is WITHIN the period of 19 months from the priority date as extended by virtue of Rule 80.5.
- ☐ Although the date of receipt of the demand is after the expiration of 19 months from the priority date, the delay in arrival is EXCUSED pursuant to Rule 82.

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Demand received from IPEA on:

PATENT COOPERATION TREATY

PCT

NOTIFICATION CONCERNING SUBMISSION OR TRANSMITTAL OF PRIORITY DOCUMENT

(PCT Administrative Instructions, Section 411)

From the INTERNATIONAL BUREAU

To:

FISHER ADAMS KELLY
Level 13
AMP Place
10 Eagle Street
Brisbane, Queensland 4000
AUSTRALIE

Date of mailing (day/month/year) 14 December 1999 (14.12.99)	
Applicant's or agent's file reference 2/7425/PC-MA	IMPORTANT NOTIFICATION
International application No. PCT/AU99/00873	International filing date (day/month/year) 12 October 1999 (12.10.99)
International publication date (day/month/year) Not yet published	Priority date (day/month/year) 12 October 1998 (12.10.98)
Applicant ASTRACON INC. et al	

1. The applicant is hereby notified of the date of receipt (except where the letters "NR" appear in the right-hand column) by the International Bureau of the priority document(s) relating to the earlier application(s) indicated below. Unless otherwise indicated by an asterisk appearing next to a date of receipt, or by the letters "NR", in the right-hand column, the priority document concerned was submitted or transmitted to the International Bureau in compliance with Rule 17.1(a) or (b).
2. This updates and replaces any previously issued notification concerning submission or transmittal of priority documents.
3. An asterisk(*) appearing next to a date of receipt, in the right-hand column, denotes a priority document submitted or transmitted to the International Bureau but not in compliance with Rule 17.1(a) or (b). In such a case, **the attention of the applicant is directed** to Rule 17.1(c) which provides that no designated Office may disregard the priority claim concerned before giving the applicant an opportunity, upon entry into the national phase, to furnish the priority document within a time limit which is reasonable under the circumstances.
4. The letters "NR" appearing in the right-hand column denote a priority document which was not received by the International Bureau or which the applicant did not request the receiving Office to prepare and transmit to the International Bureau, as provided by Rule 17.1(a) or (b), respectively. In such a case, **the attention of the applicant is directed** to Rule 17.1(c) which provides that no designated Office may disregard the priority claim concerned before giving the applicant an opportunity, upon entry into the national phase, to furnish the priority document within a time limit which is reasonable under the circumstances.

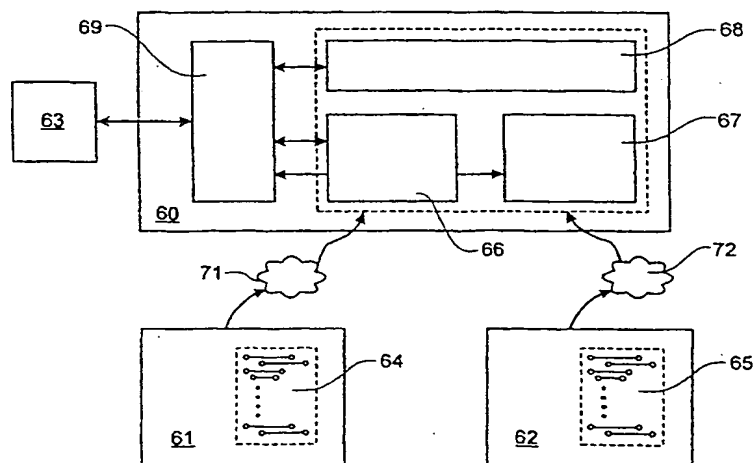
<u>Priority date</u>	<u>Priority application No.</u>	<u>Country or regional Office or PCT receiving Office</u>	<u>Date of receipt of priority document</u>
12 Octo 1998 (12.10.98)	PP 6443	AU	08 Dece 1999 (08.12.99)

<p style="text-align: center;">The International Bureau of WIPO 34, chemin des Colombettes 1211 Geneva 20, Switzerland</p> <p>Facsimile No. (41-22) 740.14.35</p>	<p>Authorized officer</p> <p style="text-align: right;">Taïeb Akremi </p> <p>Telephone No. (41-22) 338.83.38</p>
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INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification ⁶ : H04L 12/66, H04Q 3/00	A1	(11) International Publication Number: WO 00/22788 (43) International Publication Date: 20 April 2000 (20.04.00)
(21) International Application Number: PCT/AU99/00873 (22) International Filing Date: 12 October 1999 (12.10.99) (30) Priority Data: PP 6443 12 October 1998 (12.10.98) AU (71) Applicant (for all designated States except US): ASTRACON INC. [US/US]; 10303 East Dry Creek Road, Suite 250, Englewood, CO 80112 (US). (72) Inventor; and (75) Inventor/Applicant (for US only): ROSE, Ian, Alexander [AU/AU]; 16 Pedley Street, Wavell Heights, QLD 4012 (AU). (74) Agent: FISHER ADAMS KELLY; Level 13, AMP Place, 10 Eagle Street, Brisbane, QLD 4000 (AU).		(81) Designated States: AU, CA, IL, JP, KR, US, ZA, European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE). Published With international search report.

(54) Title: MANAGEMENT OF PATH SELECTION IN A COMMUNICATIONS NETWORK



(57) Abstract

A connection manager (60) is provided for selecting paths from a plurality of paths (64, 65) available from service providers (61, 62) in a communications network to route broadband traffic in the network. The connection manager (60) includes a connection model (66) indicating functional features supported by each path in the network and locations of terminations for respective paths; a cost model (68) associated with the connection model that exposes the cost of using the functional features for each path (64); and a processing means (69). The processing means of the connection manager is operative, in response to a client (63) requirement for a connection with desired features between specified locations in the network, first to identify, from the connection model (66) in light of the desired features, suitable candidate paths for routing communications traffic between the specified locations and, secondly to determine from the candidate paths and on the basis of cost exposed by the cost model (69), an optimal selection of paths connecting said locations.

PATENT COOPERATION TREATY

PCT 09/807338

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

(PCT Article 36 and Rule 70)

REC'D 18 OCT 2000

WIPO

PCT

Applicant's or agent's file reference 2/7425/PC	FOR FURTHER ACTION	See Notification of Transmittal of International Preliminary Examination Report (Form PCT/IPEA/416).
International application No. PCT/AU99/00873	International filing date (day/month/year) 12 October 1999	Priority Date (day/month/year) 12 October 1998
International Patent Classification (IPC) or national classification and IPC Int. Cl. ⁷ H04L 12/66, H04Q 3/00		
Applicant ASTRACON INC et al		

1. This international preliminary examination report has been prepared by this International Preliminary Examining Authority and is transmitted to the applicant according to Article 36.
2. This REPORT consists of a total of 3 sheets, including this cover sheet.
☒ This report is also accompanied by ANNEXES, i.e., sheets of the description, claims and/or drawings which have been amended and are the basis for this report and/or sheets containing rectifications made before this Authority (see Rule 70.16 and Section 607 of the Administrative Instructions under the PCT).

These annexes consist of a total of 7 sheet(s).
3. This report contains indications relating to the following items:

I	<input checked="" type="checkbox"/> Basis of the report
II	<input type="checkbox"/> Priority
III	<input type="checkbox"/> Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
IV	<input type="checkbox"/> Lack of unity of invention
V	<input checked="" type="checkbox"/> Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement
VI	<input type="checkbox"/> Certain documents cited
VII	<input type="checkbox"/> Certain defects in the international application
VIII	<input type="checkbox"/> Certain observations on the international application

Date of submission of the demand 2 May 2000	Date of completion of the report 9 October 2000
Name and mailing address of the IPEA/AU AUSTRALIAN PATENT OFFICE PO BOX 200, WODEN ACT 2606, AUSTRALIA E-mail address: pct@ipaustalia.gov.au Facsimile No. (02) 6285 3929	Authorized Officer DALE E. SIVER Telephone No. (02) 6283 2196

I. Basis of the report

1. With regard to the **elements** of the international application:*
- ☐ the international application as originally filed.
- ☒ the description, pages **1-3,7-25** as originally filed,
pages , filed with the demand,
pages **4,5,6** received on **18 September 2000** with the letter of **18 September 2000**
- ☒ the claims, page **26** as originally filed,
pages as amended (together with any statement) under Article 19,
pages , filed with the demand,
pages **27-30** received on **18 September 2000** with the letter of **18 September 2000**
- ☒ the drawings, Figures **1-18**, as originally filed,
pages , filed with the demand,
pages , received on with the letter of
- ☐ the sequence listing part of the description:
pages , as originally filed
pages , filed with the demand
pages , received on with the letter of
2. With regard to the **language**, all the elements marked above were available or furnished to this Authority in the language in which the international application was filed, unless otherwise indicated under this item.
These elements were available or furnished to this Authority in the following language which is:
- ☐ the language of a translation furnished for the purposes of international search (under Rule 23.1(b)).
- ☐ the language of publication of the international application (under Rule 48.3(b)).
- ☐ the language of the translation furnished for the purposes of international preliminary examination (under Rules 55.2 and/or 55.3).
3. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, was on the basis of the sequence listing:
- ☐ contained in the international application in written form.
- ☐ filed together with the international application in computer readable form.
- ☐ furnished subsequently to this Authority in written form.
- ☐ furnished subsequently to this Authority in computer readable form.
- ☐ The statement that the subsequently furnished written sequence listing does not go beyond the disclosure in the international application as filed has been furnished.
- ☐ The statement that the information recorded in computer readable form is identical to the written sequence listing has been furnished
4. ☐ The amendments have resulted in the cancellation of:
- ☐ the description, pages
- ☐ the claims, Nos.
- ☐ the drawings, sheets/fig.
5. ☐ This report has been established as if (some of) the amendments had not been made, since they have been considered to go beyond the disclosure as filed, as indicated in the Supplemental Box (Rule 70.2(c)).**

* Replacement sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this report as "originally filed" and are not annexed to this report since they do not contain amendments (Rules 70.16 and 70.17).

** Any replacement sheet containing such amendments must be referred to under item 1 and annexed to this report

V. Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement**1. Statement**

Novelty (N)	Claims 1-28	YES
	Claims	NO
Inventive step (IS)	Claims 1-28	YES
	Claims	NO
Industrial applicability (IA)	Claims 1-28	YES
	Claims	NO

2. Citations and explanations (Rule 70.7)

D1 WO99/17506 (Ericsson) 8 April 1999 and NO 97447 29 September 1997

D2 WO 94/28683 (British Telecom) 8 December 1999

D3 WO 98/21858 (MCI Communications) 22 May 1998

D4 GB 2299240 (Northern Telecom) 25 September 1996

Novelty

The prior art documents (listed above) located in the search are relevant to the claims of the present invention because they use a cost model to manage connections in a telecommunications network. The prior art documents do not make a distinction between a connection model and a cost model in managing the connections. Furthermore they do not explicitly "expose" the clients to cost or functional features.

The claims satisfy novelty requirements of the PCT.

Inventive Step

A connection manager such as defined in the claims would not be obvious to a person skilled in the art. The claims also satisfy inventive requirements of the PCT.